AD A128158

VOLUME 15, NO. 4
APRIL 1983

THE SHOCK AND VIBRATION DIGEST

A PUBLICATION OF
THE SHOCK AND VIBRATION INFORMATION CENTER
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.

OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

THE SHOCK AND VIBRATION DIGEST

Volume 15, No. 4
April 1983

STAFF

BOARD OF EDITORS

The Shock and Vibration Digest is a monthly publication of the Shock and Vibration Information Center. The goal of the Digest is to provide efficient transfer of sound, shock, and vibration technology among researchers and practicing engineers. Subjective and objective analyses of the literature are provided along with news and editorial material. News items and articles to be considered for publication should be submitted to:

Dr. R.L. Eshleman
Vibration Institute
Suite 206, 101 West 55th Street
Clarendon Hills, Illinois 60514
(312) 654-2254

Copies of articles abstracted are not available from the Shock and Vibration Information Center (except for those generated by SVIC). Inquiries should be directed to library resources, authors, or the original publishers.

This periodical is for sale on subscription at an annual rate of $140.00. For foreign subscribers, there is an additional 25 percent charge for overseas delivery on both regular subscriptions and back issues. Subscriptions are accepted for the calendear year, beginning with the January issue. Back issues are available - Volumes 9 through 14 - for $20.00. Orders may be forwarded at any time to SVIC, Code 5804, Naval Research Laboratory, Washington, DC. 20375. Issuance of this periodical is approved in accordance with the Department of the Navy Publications and Printing Regulations, NAVEXOS P-35.

A publication of

THE SHOCK AND VIBRATION
INFORMATION CENTER

Code 5804, Naval Research Laboratory
Washington, DC 20375
(202) 767-2220

SVIC NOTES

Effective April 30, 1983, I will retire from federal service after nearly 32 years of service. As always in situations like this, it is both a sad and happy occasion. My sadness comes from leaving an outstanding organization which has been so much a part of me for most of my professional career. The work has been demanding but the rewards have been great. I will surely miss my job at SVIC, yet the prospect of facing my new challenges is very exciting. In my "second career" I will happily still be interacting with many of my old friends.

Since this will be my last column as Director of SVIC, it seems appropriate to offer a few reflections on SVIC in particular and technical information in general. SVIC was born from a need to pull together the technology in the shock and vibration field and, through effective technical information support, develop a coordinated attack on difficult problems that had to be solved. Progress feeds on progress. The technological breakthroughs that are solutions to problems become a part of the SVIC archives, and the support from this information collection provides a basis for the solution of new problems that are continually arising. It is a never ending process, but one that is essential. The consequences of not sharing new technological developments are far reaching. The costs in time and money to researchers with no access to new technology can be very high. For these reasons, the information exchange process is very important and SVIC is proud to be a part of it.

The technical information area has always been a kind of stepchild. It has been difficult at times to convince R&D management to share a small percentage of their precious dollars to support technical information activities. In spite of this, we have made considerable progress. In DOD, for example, the prospects look brighter than ever. Dr. Leo Young, Director of Research and Laboratory Management, OUSDRE, is also responsible for technical information. Dr. Young is taking several actions to breathe new life into the DOD Scientific and Technical Information Program. Technical information support for DOD and its contractors should be better than ever. But we cannot afford to be complacent. Spread the word at every opportunity that information is the key to success and that progress is enhanced by awareness.

On a personal note, I cannot move along without publicly thanking the SVIC staff. This is an outstanding group of people dedicated to making this SVIC service the best there is. Rudy Volin and Gordan Showalter are there to respond to information requests and to do a thousand and one other things necessary to keep the SVIC technical side on track. Our administrative staff, headed by Jessica Hileman, keep all the details of the day-by-day operation under control. Jessica manages arrangements for the symposia, publications processing and many other details. Betty McLaughlin, among other things, handles the SVIC "bookstore" and annual subscriber service. Last, but not least, our permanent intermittent, Mary Gobbett, provides extremely effective clerical support. My most difficult problem is to leave this extraordinary staff. Without their support, SVIC could not have done nearly as well as it did.

To Ron Eshleman and his staff at the Vibration Institute, I offer my sincere thanks for a terrific job in producing this Digest. Finally, to all users and friends of SVIC, my appreciation for your support and good wishes. Farewell and smooth sailing to all.

H.C.P.

NRL $140.00

EDITORS RATTLE SPACE

HENRY PUSEY RETIRES FROM SVIC

It is with regret that I note that Mr. Henry C. Pusey, who served as Director of the Shock and Vibration Information Center (SVIC) for almost 10 years, will retire from government service on 30 April, 1983. During these ten years Henry worked tirelessly to guide SVIC through transitions in funding policies, service requirements, and technology. He successfully initiated and developed many innovative approaches to information-oriented services to utilize government and industry R&D funds more efficiently.

Henry began his service at SVIC under its founder Dr. Elias Klein in 1953 as the U.S. Army representative to the Technical Advisory Group. The application of shock and vibration technology to the design and development of equipment was then in its growth stage. SVIC served as a focal point for the development and dissemination of shock and vibration technology. In 1958 Henry joined the SVIC staff of experts in shock and vibration design, analysis, and testing. SVIC conducted many successful symposia and played an important role in the practical application of new technology.

During these years SVIC also initiated publication of a monograph series to distill published technology and **The Shock and Vibration Digest** to provide an efficient means for dissemination of a vast literature to shock and vibration engineers. SVIC also contributed to the development of standards, codes, and criteria.

Henry succeeded Dr. Robert Belsheim to become the fourth Director of SVIC in 1973. Under his innovative leadership new and expanded information services were initiated and developed. The monograph series was continued and its scope expanded, an international survey of shock and vibration technology was published as was a monograph on the management of shock and vibration technology. **The Shock and Vibration Digest** initiated a new series of articles on subjective reviews of the literature. His idea for plenary sessions, including the Elias Klein Memorial lecture, became reality at the 50th Shock and Vibration Symposium in 1979. These sessions have continued to provide new and interesting dimensions to information exchange. Henry supported and spent much time on standards activities and with technical societies. His vision for integrating shock and vibration technology into total survivability and vulnerability environments is close to reality. Thus SVIC, under Henry's leadership, has not only fulfilled its original mission but also has become an innovator, initiator, and developer -- even during periods of transitions in funding and service requirements.

Henry will continue to be an active participant in the affairs of the shock and vibration community as he undertakes new challenges in the private sector. Without a doubt he will continue to make major contributions to the development and use of technology as well as its effective dissemination. On behalf of the **DIGEST** staff, I wish to extend all good wishes to Henry in his new endeavors.

R.L.E.

VIBRATION ANALYSIS OF PISTON ENGINES WITH APPLICATION TO NOISE CONTROL

M.G. Milsted*

Abstract. Literature from 1958 to early 1982 concerned with high frequency vibration and noise from piston engines is surveyed. Problems associated with characterization of the vibration source, its transmission through the engine structure and the coupling between surface vibration and radiated noise are included.

Noise from vehicles powered by piston engines, particularly diesel engines, has been recognized as a serious problem in industrialized countries since the early 1960s. Control of vehicle noise is, of course, a many faceted problem; it involves not only several aspects of vehicle deisgn but also, in urban environments, the imposition of constraints on the siting of roadways and the noise insulation standards of buildings. In fact, legislative restrictions and commercial incentives related to various aspects of the noise problem now play important parts in the design and development of both vehicles and road networks.

Engine noise, which is the most important component of vehicle noise, is comprised of noise radiated from the engine itself as well as from the inlet, the exhaust, the cooling fan, the fuel pump, and other ancilliary components. Of these sources, noise from the basic engine structure has been the most difficult to deal with; satisfactory engineering solutions to the control of other sources was largely achieved by the mid 1970s.

Noise from the engine itself results principally from the forces of combustion and the mechanical forces arising from the motions of the crank train, valve train, and fuel injection pump. These forces are propagated through the structure in a broad frequency band and give rise to vibrations on the engine surface that radiate energy in the form of sound waves. Three classes of problems can be identified: characterization of the various sources and their interactions, determination of the mechanisms by which vibrations are transmitted through the structure, and study of the coupling process between surface vibration and radiated noise. These topics are the subjects of this review.

The review is organized chronologically: early work, the period to 1973; middle years, from 1974 to 1979; and current work, from 1980 to mid 1982. Most of the work has been concerned with diesel engines; substantial contributions have come from Europe, Japan, and the United States. Fortunately, representative descriptions of the work from Europe and Japan have appeared in English language publications; references to work that originally appeared in a foreign language are not included in the list of references. The review is, strictly speaking, incomplete in another sense due to the practice of publishing what is essentially the same material in more than one place. In this regard an attempt has been made to select the more basic publications as opposed to those that are of a summary nature.

THE PERIOD TO 1973

Although earlier work concerned with engine noise exists, perhaps the place to start is with that of Austen and Priede [1], who in the late 1950s measured spectral characteristics of the noise and vibration from several diesel and petrol engines. They established the strong dependency of noise on engine speed, as well as the importance of the mid-frequency range of 800 to 2000 Hz on overall noise level. In addition, they agreed with earlier observations [2] concerning the relationship between the shape of a cylinder pressure diagram – particularly the rapid rise that occurs in a diesel engine after combustion --

*University of Technology, Department of Transport Technology, Loughborough, Leicestershire LE11 3TU, UK

and its high frequency spectral content. The relation between the form of cylinder pressure rise and noise was further explored by Priede [3], who also introduced the concept of the critical cylinder-pressure spectrum as the condition under which combustion and mechanical noise are equal. He also described changes in the combustion process as a means of noise control.

Alterations to the form of basic engine structure as a means of noise control were also the subject of several papers by Priede and his co-workers [4-6]. After determining experimentally that vibration of crankcase walls is responsible for much radiated noise, they proposed two concepts for its reduction. One was based on a very stiff load-carrying frame to which thin highly-damped side panels were attached. The principle behind the second concept was that noise would be greatly reduced if the bending stiffness of the block could be significantly increased without a corresponding increase in mass. This concept was realized by making the crankcase from a magnesium casting. Prototype four-cylinder engines based on each concept showed noise reductions of about 10 dB(A) over conventional engines. In further studies of engine structure [7] some lower modes of vibration of both in-line and V-engine blocks are given, as are effects on modal responses of various forms of stiffeners. An extension of the work [8], which includes simple empirically-derived formulas for predicting the basic cylinder block frequencies, offered guidelines for designing low noise engines.

The advantages of making engine noise measurements in an anechoic environment were noted by Thien [9], who also proposed using an acoustic duct to measure noise contributed by individual components. He suggested close fitting enclosures as a means of noise control; this concept has been developed further over the years [10-12]. Thien also discussed experimental methods for determining the relative importance of the two structure-borne paths -- cylinder head to block or crank train to block -- by which combustion forces are transmitted to the exterior surfaces of an engine.

During this early period the importance of such mechanical noise sources as piston slap, timing gears, and the fuel injection pump came to be recognized. Analyses of piston slap -- the impact resulting from the external movement of a piston across the clearance in a cylinder base -- were made by several investigators [13-17]. Also in this period were published the results of experiments in which the position of a piston in a bore had been measured in a running engine using piston-mounted inductive transducers [18]. These analyses identified both theoretically and experimentally the existence and timing of piston slap in the crank cycle and provided qualitative information that has been used in engine design; however, they did not fully explain the relationships between the slap event and surface vibration. Of interest is a paper [19] in which are included a general discussion of mechanical noise sources and examples of resonance behavior in the connecting rod and the crankshaft.

The relationship between surface vibration and radiated noise of engines and thin components came under scrutiny in the latter part of this early period. Chan and Anderton [20, 21] made extensive measurements of surface vibration and noise on a range of diesel engines. They established a broad similarity between mean square vibration velocity and noise measured in one-third octave bands at frequencies above 400 Hz. Radiation efficiencies for modes of bending vibration of baffled beams and plates were calculated by Wallace [22, 23]. He numerically evaluated Rayleigh's integral for the farfield pressure distribution. His results for plates have been widely used as a basis for calculating noise radiation from engines. One such calculation procedure is available [24].

A final noteworthy contribution to this period was the development of empirically-based noise prediction formulas that have proved useful in vehicle design. Formulas accurate to ±2 dB(A) for a wide range of engines have been published [25, 26]. The data required are bore size, engine speed, and the type of combustion system.

The chronological boundaries of this review have been drawn on the basis of the methodology used. Experimental work of the early years was characterized by the use of analog instrumentation and signal processing equipment. Because constant percentage bandwidth spectrum analyzers were used almost exclusively, much detail was lost at high frequencies. Similar problems existed in theoretical studies because structural models of engines were limited to simple beam and plate representations. It

is not surprising, therefore, that close examination of the work of this period reveals certain contradictions as well as arguments and practices that are now dubious. Nevertheless, the considerable noise and vibration data acquired for a wide range of engines during this time provided a sound basis for applying the more advanced techniques that were rapidly becoming available. Interesting summaries of the state of the art in this period have been written by individuals in the field [27, 28] and out of it [29, 30].

THE PERIOD FROM 1974 TO 1979

By the mid 1970s most groups working on engine noise had access to digital FFT signal processing computers and to general purpose finite element (FE) programs. The theory behind the new technology was better established than were practical aspects, however, so that this period can be considered a transition from old ways to new. Much of the work of these years was presented at two conferences on diesel engine noise sponsored by the SAE [31, 32]; many of the papers are referred to below.

Vibration response of the engine block was the main subject of several papers. Time-averaged holography was used to measure transfer functions and mode shapes of a static V10 engine at frequencies up to 3000 Hz [33]. Modes of vibration that were efficient noise radiators were identified, and the results of an FE vibration analysis of a simple flat plate representation of an engine block were reported.

Lalor and Petyt [34] also studied several aspects of block vibration. They showed the similarity between static deflection of a point force-loaded block and the deflection on patterns of selected modes in a running engine and modeled the problem with a simple beam-plate FE model. They also analyzed boxlike structures that closely resembled an engine and various mechanisms of force transmission in an engine structure. Mode shapes obtained by impulsive excitation using a hammer and by analysis of running engine data were compared with a two-channel FFT system [35]. Mode shapes measured on a static engine with time-averaged holography and running engine data were also published [36]. Extensive information on transfer functions and mode shapes was given [37] for three and five main bearing versions of four-cylinder engines. Differences among the responses of the bare block, the built up, and the running engine were discussed. A detailed analysis of narrow band vibration spectra in the 0 - 5000 Hz range measured on the block of a running engine was given by Marples [38], who found that the response contained both harmonic and inharmonic components of combustion force. He argued that speed variations, even at a nominally steady speed, were sufficient to excite the densely packed high frequency modes of the engine into natural vibration thus giving rise to the inharmonic components in the response spectra. This paper and another [39] contain interesting comments on the work of the early years.

Another aspect of the problem was the transfer of vibration from the moving crank train to the stationary parts of the structure. DeJong [40, 41] showed that mobility methods can be used to model the combustion force transmission path through the crank train to external engine surfaces. He used simple models of the subsystems -- discrete element models of the crank train and statistical models of the block and covers -- to make useful predictions of the transfer mobility to a frequency of about 4 kHz. The coupling of an n^{th} order torsional vibration with translational forces of orders $n \pm 1$ at the main bearings and the effect of these forces on radiated noise were described [42].

Applications of noise control technology in the early part of this period are available [43, 44]. Source identification techniques were described and various applications for stiffening, isolation, and damping were evaluated. The use of vibration isolation techniques in the design of an experimental engine was described [45].

The usefulness of predictive techniques was advanced considerably between 1974 and 1979. Finite element methods came to be accepted as an accurate but expensive way to predict natural frequencies and mode shapes of engine components throughout the frequency range of interest. Examples of accomplishments are available [46-49]. Solution strategies varied as did methods for evaluating the effects of structural changes. For example, NASTRAN was used to reduce a 9500 degree-of-freedom model of an in-line block to 144 degrees of freedom using mass condensation [46]. The low-order modes of a 6400 degree-of-freedom NASTRAN model were extracted

using the inverse power method with shifts without mass condensation [48]. SPADAS was used in a multiple sub-structuring technique, apparently the Craig-Bampton method, in which mass condensation was used to control the size of the problems [47].

A different approach was taken by Lalor [50], who introduced a static optimization scheme based on a two-dimensional model of a block section passing through a main bearing web. He argued that the forced response of the block in the important one-third octave bands is controlled by off-resonant contributions from the modes of vibration and further that the flexibility of these modes is more important than their inertia. He thus concluded that static stiffness could be used as a criterion in designing a low-noise engine. Another example of this approach has been published [51].

A predictive approach based on a flat plate idealization of an engine structure has been described [52]. The plates used in the idealization were assumed to vibrate independently of each other; noise predictions were based on known radiation efficiencies of simple plates. Extensions of the method are available [53, 54].

Several papers [55-59] dealing with piston slap compare the results of experiments on running engines with the results of computer simulations. In general the theoretical models (of which only brief descriptions are given in the references listed) account for the effects of gas pressure, inertia, and friction forces in broadly similar ways. These models can be used to predict piston attitude and the severity of piston-cylinder impacts. None of the analyses accounts for the dynamics of the engine block. A slightly different approach [60] included a two-mode approximation of cylinder liner vibration in an analog simulation that allowed only for translational motion of the piston.

Noise and vibration analysis procedures were greatly improved during this middle period by the ready availability of digital processing equipment. Of particular importance was work concerned with determining the noise radiated from individual components or specific areas of an engine structure. The techniques for determining contributed levels available in 1974 -- near field sound pressure measurement, the lead-unwrapping technique, measurements in an acoustic duct, and surface vibration measurements -- have been reviewed [61]. Efforts required to make high quality noise measurements have been described [62].

Cross-correlation between surface vibration and noise in a semi-reverberant environment as a way to identify the dominant noise sources on a railroad diesel engine have been discussed [63]. Some of the problems associated with applying correlation techniques to the analysis of engine-related vibrations in a tractor have been given [64]. A summary of work using coherence techniques and multi-input, single-output models to describe the noise transmission process is available [65].

The most important advance in measurement technique, however, was the recognition [66, 67] that acoustic intensity could be determined from the cross-spectral density function of two closely spaced microphones. This advance has provided the basis for a relatively simple method of directly determining the sound intensity radiated from an arbitrary surface in any acoustic environment. The application of the technique to engine noise evalution has been described [68].

CURRENT WORK

The literature since 1979 shows a more refined use of techniques developed in the 1970s. For example, the objective of an FE analysis before 1979 was often simply to predict natural frequencies and mode shapes of major engine components. Emphasis now is much more firmly aimed at modeling the complete engine structure with realistic representations of the principal forcing functions. Similarly on the experimental side questions related to the identification of significant vibration transmission paths and component noise radiation levels are being examined in a much more comprehensive manner than was previously the case.

Again many papers of interest appear in the proceedings of two conferences, one organized by the SAE [69] and the other by General Motors Research Laboratories [70]. The latter, which includes some interesting discussions of the papers, provides an excellent assessment of the state of the art of the techniques of noise and vibration analysis of engines

and of low-noise design. Of general interest is the book edited by Baxa [71], which covers the broad field of engine noise control and testing procedures including silencers, cooling systems, and accessories as well as noise from basic engine structures. Most of the modern techniques of vibration and noise analysis are mentioned, but their applications are described only in general terms. Also of interest is an extensive review paper by Priede [72] citing 120 references and covering the entire period of development of the internal combustion engine.

Several papers concerned with identifying the transmission paths associated with combustion noise have appeared. Affenzeller and Thien [73] studied an engine in which the crank train was the dominant path. Accelerations measured on a running four-cylinder, diesel engine showed that most of the motion occurred within 30° - 40° of top-dead-center (TDC). The authors concluded that crank train stiffness is substantially constant in this range. Oil-film stiffness at the bearings was found to have a minor effect on vibration transmission through the crank train. Calculations from a simple FE model were in broad agreement with experimental results. Results of another experimental study on a four-cylinder diesel engine in which the transmission path through the cylinder head was as important as the crank train have been given by Okamura [74]. He showed that valve seating impacts can excite the side walls of the cylinder block. In an interesting experiment on a four-cylinder petrol engine oil-film thicknesses and forces were measured at the main bearings [74]. The vibrations of the bearing panels and the crankshaft deformation had an influence on the load transfer at individual bearings; bearing panel motions were coupled with those of the cylinder side walls.

DeJong and Parsons [76] measured component mobilities in a non-running four-cylinder, diesel engine. They developed a model for combustion noise transmission through the crank train and the cylinder head. Calculations based on the assumption that vibration in the crank train is important only around TDC showed that the crank train was the dominant path up to a frequency of 1.6 kHz; at this point both paths were of approximately equal importance. The transfer mobility measured between the gas force and the big end motion on a running engine broadly agreed with an analysis based on data from a non-running engine. Other studies with generally similar aims and methods are available [77, 78].

Many papers [79-88] discuss the use of various forms of experimental modal analysis and FE modeling in support of low-noise design studies. The importance of experimental modal analysis as a guide to FE analysis has been stressed by Challen and Croker [79], who described some of their FE models. They recommend semi-loof beam and shell elements. Hayes and Quantz [80] discussed the advantages of using running engine-forced deflection patterns as opposed to static modal analysis as a means of experimentally verifying FE models. They also described the calculation of radiated noise from an FE model using piston-in-baffle theory and presented some interesting results concerning measured and calculated radiated efficiencies of various components. Ochiai [81, 82] described a comprehensive study using laser holography and FE analysis to develop a lightweight, low-noise design of a six-cylinder diesel engine. A static optimization scheme has been extended to three-dimensional FE models [83, 84].

A different approach to the analysis of FE models has been proposed [89, 90]. Natural frequencies and mode shapes of an engine block and a crankshaft were obtained from a dynamic stiffness coupling technique. The order of the eigenvalue problem was equal to the number of coupling coordinates between the substructures. One advantage of the method is that the coupling process is exact; a disadvantage is that the coordinates not involved in the coupling process must be eliminated at every frequency in the determinant search eigenvalue procedure.

Study of mechanical noise sources in engines has also continued. DeJong and Parsons [91, 92] described work on a turbocharged V8 engine in which piston slap and fuel injector forces are primary noise sources. They described an experimental technique for determining the piston slap force and a revised cylinder liner design that reduces vibration transmission to the cylinder block. Slack [93] used similar methods to show the importance of bending vibrations in the connecting rod as a mechanism for transmitting piston slap forces through the crank train of a four-cylinder engine. In a simple discrete element model of a piston-cylinder liner impact [94] the liner is assumed to deform in an oval-shaped

mode. A review of fuel injection system noise has been given [95].

A general computational procedure for calculating vibration and noise radiation from impacting mechanisms undergoing large motions has been presented [96]. A Helmholtz integral equation formulation of the sound pressure field was developed. The incorporation of FE models of mechanism members into the framework of an analysis has been described [97]. These methods appear to have considerable potential.

Much attention is being focused on the development of intensity measuring techniques. Measurement techniques with and applications of the two-microphone method have been described [98, 99]. Developments in intensity probe design and in the use of a digital filter-based analysis system [100] -- as opposed to an FFT system -- have been published. Several theoretical analyses [102-105] of errors associated with two-microphone intensity measurements have also been made. A surface intensity technique using a microphone and an accelerometer was developed by McGary and Crocker [106, 107]. Crocker [108, 109] also compared various experimental methods of noise source identification as did Abe and Anderton [110]. The use of a laser doppler system for surface velocity measurement has been given as has a useful compilation of vibration measurements on a variety of engines [111].

The utility and accuracy of the acoustic intensity method for engine noise work now seem to be generally accepted. It is not, however, a complete experimental tool because, in many applications, surface vibration measurements are also required.

Finally, a method for computing the sound radiated from a closed vibrating surface using the Helmholtz integral equation has been developed [112, 113]. The calculation is based on a triangular/rectangular discretization -- intended to be compatible with an FE mesh -- of the surface and requires modal vibration characteristics as input.

SUMMARY AND CONCLUSIONS

Within the last two decades a great deal has been learned about engine noise and vibration. The major parameters are known, and, within the framework of conventional designs, the various ways of minimizing noise are reasonably well understood. In terms of satisfying the need for quieter vehicles, however, much remains to be done. It is generally accepted that the best hope for noise reduction lies with the design of the engine structure; progress in this direction will no doubt come from a combination of innovative design and careful analysis.

The general applicability and usefulness of modern techniques of noise and vibration analysis to the engine noise problem has been demonstrated both experimentally and theoretically. Possibilities for further application of these established techniques are substantial. Certainly a more refined use of finite element-based models can be expected -- one that incorporates better representations of force-generating mechanisms and damping mechanisms. Substructuring techniques can undoubtedly be used to advantage, perhaps not so much as a means of controlling computational requirements as a tool for increasing physical understanding of the interactions between components. Efficient structural re-analysis and optimization techniques would also seem to be subjects for further study.

Further development of part theoretical/part experimental modeling techniques that yield fairly simple descriptions of engine dynamics should be encouraged because these methods have proven their value in transmission path studies.

The measurement and calculation of the sound radiating characteristics of engine components are obviously going to stimulate considerable work. However, minor structural components often contribute significantly to total engine noise; the difficulties in developing a predictive model for noise radiation from a complete engine should therefore not be underestimated. The motivation to produce quieter engines remains high, and considerable progress can be expected in the next few years.

REFERENCES

1. Austen, A.E.W. and Priede, T., "Origins of Diesel Engine Noise," Symposium on Engine Noise Suppression, I Mech E, Proc. 173, pp 19-32 (1958).

2. Hintz, J.O., "Effect of Cylinder Pressure on Vibrations," ASME Paper No. 49-OGP-3 (1949).

3. Priede, T., "Relation between Form of Cylinder Pressure Diagram and Noise in Diesel Engines," I Mech E, Proc. (A.D.), pp 63-77 (1960-61).

4. Priede, T., "Noise due to Combustion in Reciprocating Internal Combustion Engines," Advances in Automobile Engineering, (Part III) Noise and Vibration, Pergamon Press, pp 93-128 (1964).

5. Priede, T., Austen, A.E.W., and Grover, E.C., "Effect of Engine Stucture on Noise of Diesel Engines," I Mech E, Proc. 179, Pt. 2A, pp 113-143 (1964-65).

6. Austen, A.E.W. and Priede, T., "Noise of Automotive Diesel Engines: Its Causes and Reduction," SAE Trans. 74, Paper 650165 (1966).

7. Priede, T., Grover, E.C., and Lalor, N., "Relation between Noise and Basic Structural Vibration of Diesel Engines," SAE Prepr. 690450 (1969).

8. Jenkins, S.H., Lalor, N., and Grover, E.C., "Design Aspects of Low-Noise Diesel Engines," SAE Trans., 82 (2), pp 969-985 (1973).

9. Thien, G.E., "Methods and Problems in Noise Reduction on High Speed Diesel Engines," SAE Trans., 77, pp 1394-1406 (1968).

10. Thien, G.E., "The Use of Specially Designed Covers and Shields to Reduce Diesel Engine Noise," SAE Trans., 82 (2), pp 955-968 (1973).

11. Thien, G.E., "A Review of Basic Design Principles for Low-Noise Diesel Engines," SAE Prepr. 790506 (1979).

12. Thien, G.E., "The Use of Enclosures for Reducing Engine Noise," Engine Noise: Excitation, Vibration, and Radiation, pp 345-385, Plenum Press (1982).

13. Ungar, E.E. and Ross, D., "Vibrations and Noise Due to Piston-Slap in Reciprocating Machinery," J. Sound Vib., 2, pp 132-146 (1965).

14. Griffiths, W.J. and Skorecki, J., "Some Aspects of Vibration of a Single Cylinder Diesel Engine," J. Sound Vib., 1, pp 345-364 (1964).

15. Fielding, B.J., "Identification of Mechanical Sources of Noise in a Diesel Engine," Ph.D. Thesis, University of Manchester (1968).

16. Fielding, B.J. and Skorecki, J., "Identification of Mechanical Sources of Noise in a Diesel Engine: Sound Originating from Piston Slap," I Mech E, Proc. 184, Pt. 1, pp 859-874 (1969-70).

17. Fielding, B.J., "The Investigation of Mechanism Noise in a Diesel Engine," Third World Congr. Theory Mach. Mech. (1971).

18. Laws, A.M., Parker, D.A., and Turner, B., "Piston Movement in the Diesel Engine," 10th Intl. Conf. Combustion Engines, pp 809-833 (1973).

19. Russell, M.F., "Automotive Diesel Engine Noise and Its Control," SAE Trans. 82 (2), pp 937-954 (1973).

20. Chan, C.M.P. and Anderton, D., "The Correlation of Machine Structure Surface Vibration and Radiated Noise," Proc. Inter-Noise 72, pp 261-266 (1972).

21. Chan, C.M.P. and Anderton, D., "The Correlation between Engine Block Surface Vibration and Radiated Noise in In-Line Diesel Engines," Noise Control Engrg., 2 (1), pp 16-24 (1974).

22. Wallace, C.E., "Radiation Resistance of a Baffled Beam," J. Acoust. Soc. Amer., 51, pp 936-945 (1972).

23. Wallace, C.E., "Radiation Resistance of a Rectangular Panel," J. Acoust. Soc. Amer., 51, pp 946-952 (1972).

24. Berg, Per-Ake, "Estimation Methods of Sound Radiation Generated from Diesel Engine Installations in Ships and Prediction of the

Noise Reducing Possibilities," 10th Intl. Conf. Combution Engines (1973).

25. Anderton, D., Grover, E.C., Lalor, N., and Priede, T., "Noise due to Combustion in Reciprocating Internal Combustion Engines -- Its Characteristics, Prediction and Control," ASME Paper 70-WA/DGP-3 (1970).

26. Anderton, D. and Baker, J., "Influence of Operating Cycle on Noise of Diesel Engines," SAE Trans. 82 (2), pp 927-936 (1973).

27. Grover, E.C. and Lalor, N., "A Review of Low Noise Diesel Engine Design at I.S.V.R.," J. Sound Vib., 28, pp 403-431 (1973).

28. Raff, J.A. and Perry, R.D.H., "A Review of Vehicle Noise Studies Carried Out at the Institute of Sound and Vibration Research with Reference to Some Recent Research on Petrol Engine Noise," J. Sound Vib., 28, pp 432-470 (1973).

29. Soroka, W.W. and Chien, C.F., "Automotive Piston-Engine Noise and Its Reduction -- A Literature Survey," SAE Prepr. 690452 (1969).

30. Brammer, A.J. and Muster, D., "Noise Radiated by Internal Combustion Engines," J. Acoust. Soc. Amer., 58, pp 11-21 (1975).

31. Diesel Engine Noise Conference, SAE SP-397 (1975).

32. Diesel Engine Noise Conference, SAE Proc. P-80 (1979).

33. Ochiai, K., Aisaka, M., and Sakata, S., "Simple Model Technique for Better Understanding of Diesel Engine Vibration and Noise," SAE Trans. 84, pp 2148-2159 (1975).

34. Lalor, N. and Petyt, M., "Modes of Engine Structure Vibration as a Source of Noise," SAE Trans. 88, pp 2134-2147 (1975).

35. Aoyama, F., Tanaka, S., and Miura, Y., "Vibration Mode Analysis for Controlling Noise Emission from Automotive Diesel Engine," SAE Prepr. 790361 (1979).

36. Watanabe, Y., "Reduction of Combustion Noise and Structural Improvement of Its Transmission Path in Diesel Engine Design," Intl. J. Vehicle Des., 2, pp 276-288 (1981).

37. Anderton, D., Dixon, J., Chan, C.M.P., and Andrews, S., "The Effect of Structure Design on High-Speed Automotive Diesel Engine Noise," SAE Prepr. 790444 (1979).

38. Marples, V., "On the Frequency Content of the Surface Vibration of a Diesel Engine," J. Sound Vib., 52, pp 365-386 (1977).

39. Marples, V., "Diesel-Engined Vehicle Noise," Rept. No. ME/A 75-2, Dept. Mech. Aeronaut. Engrg., Carleton Univ., Ottawa (1975).

40. DeJong, R.G., "Vibrational Energy Transfer in a Diesel Engine," Sc.D. Thesis, Massachusetts Institute of Technology (1976).

41. DeJong, R.G. and Manning, J.E., "Modelling of Vibration Transmission in Engines to Achieve Noise Reduction," SAE Prepr. 790360 (1979).

42. Ochiai, K. and Nakano, M., "Relation between Crankshaft Torsional Vibration and Engine Noise," SAE Trans. 88, pp 1291-1298 (1979).

43. Lane, R.S., Timour, S.E., and Hawkins, G.W., "Techniques of Structural Vibration Analysis Applied to Diesel Engine Noise Reduction," SAE Prepr. 750835 (1975).

44. Kabele, D.F. and Anderkay, G.A., "Techniques for Quieting the Diesel," SAE Trans. 84, pp 2176-2184 (1975).

45. Fachbach, H.A. and Thien, G.E., "An Approach to a Quiet Car Diesel Engine," SAE Prepr. 790441 (1979).

46. Ford, D.M., Hayes, P.A., and Smith, S.K., "Engine Noise Reduction by Structural Design Using Advanced Experimental and Finite Element Methods," SAE Trans. 88, pp 1299-1306 (1979).

47. Croker, D.M., Lalor, N., and Petyt, M., "The Use of Finite Element Techniques for the

Prediction of Engine Noise," I Mech E Conf. Publ. 1979-10, pp 131-140 (1979).

48. Raibstein, A.I. and Schulze-Schwering, W.P., "Acoustic Behaviour Analysis of Engine Blocks," SAE Prepr. 790986 (1979).

49. Barbiero, D., Chiosso, T., Garro, A., and Roberi, G., "Combustion Engine Stiffness Distribution and Dynamic Response," SAE Prepr. 790987 (1979).

50. Lalor, N., "Computer Optimized Design of Engine Structures for Low Noise," SAE Trans. 88, pp 1282-1290 (1979).

51. Ruspa, G., Lalor, N., and Baker, J.M., "Computer Aided Diesel Engine Design," Proc. ISATA 80, 1, pp 253-265 (1980).

52. Hawkins, M.G. and O'Keeffe, J.M., "A Method for Determining the Effect of Design Changes on Diesel Engine Noise," 11th Intl Conf. Combustion Engines, 1, pp 653-690 (1975).

53. Hawkins, M.G. and Southall, R., "Analysis and Prediction of Engine Structure Vibration," SAE Trans., 84, pp 2123-2133 (1975).

54. Yorke, P.J., "The Application of Idealization and Response Analysis to Diesel Engine Noise Assessment," SAE Prepr. 750836 (1975).

55. Munro, R. and Parker, P., "Transverse Movement Analysis and Its Influence on Diesel Piston Design," SAE Trans. 84, pp 2002-2013 (1975).

56. Rohrle, M.D., "Affecting Diesel Engine Noise by the Piston," SAE Prepr. 750799 (1975).

57. Usami, T., Wada, S., and Sonada, S., "Piston Slap of Indirect Combustion Diesel Engine," SAE Prepr. 750801 (1975).

58. Fujimoto, Y., Suzuki, T., and Ochiai, Y., "On Piston Slap in Reciprocating Machinery," Vibrations in Rotating Machinery, I Mech E Conf. 1976-9, pp 245-253 (1976).

59. Sander, W., Steidle, W., and Wacker, E., "Piston Movement and Its Influence on Noise of Automotive Engines," SAE Prepr. 790272 (1979).

60. Haddad, S.D. and Fortesque, P.W., "Simulating Piston Slap by an Analogue Computer," J. Sound Vib., 52, pp 79-93 (1977).

61. Seybert, A.F., "Estimation of Contributed Noise Levels of Diesel Engine Components from Vibration Measurements," SAE Trans. 84, pp 683-689 (1975).

62. Trella, T., Mason, R., and Karsick, R., "External Surface Noise Radiation Characteristics of Truck Diesel Engines -- Their Far Field Signatures and Factors Controlling Abatement," SAE Trans., 87, pp 673-701 (1978).

63. Kumar, S. and Srivastava, N.S., "Investigation of Noise due to Structural Vibrations Using a Cross-Correlation Technique," J. Acoust. Soc. Amer., 57, pp 769-772 (1975).

64. Marples, V. and Ryde-Weller, A., "The Technique of Correlation, Selection of Correlation Parameters and Applications to Noise and Vibration Analysis," Applied Acoust., 12, pp 93-109 (1979).

65. Crocker, M.J. and Hamilton, J.F., "Modelling of Diesel Engine Noise Using Coherence," SAE Trans., 88, pp 1263-1273 (1979).

66. Fahy, F.J., "Measurement of Acoustic Intensity Using the Cross-Spectral Density of Two Microphone Signals," J. Acoust. Soc. Amer., 62, pp 1057-1059 (1977).

67. Chung, J.Y., "Cross-Spectral Method of Measuring Acoustic Intensity without Error Caused by Instrument Phase Mismatch," J. Acoust. Soc. Amer., 64, pp 1613-1616 (1978).

68. Chung, J.Y., Pope, J., and Feldmaier, D.A., "Application of Acoustic Intensity Measurement to Engine Noise Evaluation," SAE Prepr. 790502 (1979).

69. Engine Noise Symposium, Proc. SAE, p 106 (1982).

70. Hickling, R. and Kamel, M.M. (Eds.), Engine Noise: Excitation, Vibration and Radiation, Plenum Press (1982).

71. Baxa, D.E., (Ed.), Noise Control in Internal Combustion Engines, Wiley (1982).

72. Priede, T., "In Search of Origins of Engine Noise – an Historical Review," SAE Trans. 89, pp 2039-2069 (1980).

73. Affenzeller, J. and Thien, G.E., "Evaluating Engine Design for Low Noise Using Dynamic Structural Modelling," SAE Prepr. 820435 (1982).

74. Okamura, H., "Experiments on the Transmission Paths and Dynamic Behaviour of Engine Structure Vibrations; I: Background and Static Tests; II: Motoring Tests," J. Acoust. Soc. Amer., 67, pp 538-545, pp 546-550 (1980).

75. Ishihama, M., Hayashi, Y., and Kubozuka, T., "An Analysis of the Movement of the Crankshaft Journals during Engine Firing," SAE Trans. 90, pp 2243-2353 (1981).

76. DeJong, R.G. and Parsons, N.E., "High Frequency Vibration Transmission through the Moving Parts of an Engine," SAE Trans. 89, pp 1598-1604 (1980).

77. Hayashi, Y., Sugihara, K., Toda, A., and Ushijima, Y., "Analytical Study on Engine Vibration Transfer Characteristics Using Single-Shot Combustion, SAE Trans. 90, pp 1539-1548 (1981).

78. Nakata, S., Yoshizu, K., and Hatamura, K., "Development Work of High Speed 3.0 Liter Diesel Engine," SAE Trans., 89, pp 2954-2966 (1980).

79. Challen, B.J. and Croker, D.M., "A Review of Recent Progress in Diesel Engine Noise Reduction," SAE Prepr. 820517 (1982).

80. Hayes, P.A. and Quantz, C.A., "Determining Vibration, Radiation Efficiency, and Noise Characteristics of Structural Designs Using Analytical Techniques," SAE Prepr. 820440 (1982).

81. Ochiai, K. and Yokota, K., "Light-Weight, Quiet Automotive D.I. Diesel Engine Oriented Design Method," SAE Prepr. 820434 (1982).

82. Ochiai, K., "Dynamic Behaviour of Engine Structure Vibrations," Engine Noise: Excitation, Vibration, and Radiation, pp 179-210, Plenum Press (1982).

83. Lalor, N., "Finite Element Optimization Techniques of Diesel Engine Structures," SAE Prepr. 820437 (1982).

84. Lalor, N. and Petyt, M., "Noise Assessment of Engine Structure Designs by Finite Element Techniques," Engine Noise, Vibration, and Radiation, pp 211-244, Plenum Press (1982).

85. Birth, M.S. and Papez, S., "Idealization, Measurement and Calculation of an Engine Block," SAE Prepr. 820438 (1982).

86. Brandeis, J.P., "The Use of Finite Element Techniques to Predict Engine Vibration," SAE Prepr. 820436 (1982).

87. Moncelle, M., "Diesel Engine Sound Reduction by Dynamic Structural Modelling," SAE Prepr. 800409 (1980).

88. Nagayama, I., Araki, Y., Kakuta, K., and Usuba, Y., "Engine Noise Reduction by Structural Study of Cylinder Block," SAE Trans. 89, pp 1741-1748 (1980).

89. Nagamatsu, A., Hayashi, Y., and Ishihara, A., "Analysis of Vibration of Cylinder Block by Reduced Impedance Method," Bull. JSME, 23, pp 1879-1883 (1980).

90. Nagamatsu, A. and Nagaike, M., "Vibration Analysis of Movable Parts of Internal Combustion Engine; Part 1: Crank Shaft," Bull. JSME, 24, pp 2141-2146 (1981).

91. DeJong, R.G. and Parsons, N.E., "Piston Slap Noise Reduction in a Vee-Block Diesel Engine," SAE Prepr. 820240 (1982).

92. DeJong, R.G., "Using Vibration Transmission Analyses in the Design of Quiet Engines," Engine Noise: Excitation, Vibration, and Radiation, pp 123-146, Plenum Press (1982).

93. Slack, J.W., "Piston Slap," Engine Noise: Excitation, Vibration, and Radiation, pp 39-53, Plenum Press (1982).

94. Seybert, A.F., Hamilton, J.F., and Hayes, P.A., "Model of Piston Impact and Vibration," Arch. Acoust., 6, pp 89-110 (1981).

95. Russell, M.F., "Noise from Fuel Injection Systems and Its Control," Engine Noise: Excitation, Vibration, and Radiation, pp 95-120, Plenum Press (1982).

96. Dubowsky, S. and Perreira, N.D., "Noise and Vibration Generated by Impacts in Linkage Systems with Application to Engines," Engine Noise: Excitation, Vibration, and Radiation, pp 147-177, Plenum Press (1982).

97. Sunada, W. and Dubowsky, S., "The Application of Finite Element Methods to the Dynamic Analysis of Flexible Spatial and Coupling Linkage Sytems," J. Mech. Des., Trans. ASME, 103, pp 643-651 (1981).

98. Chung, J.Y. and Blaser, D.A., "Recent Developments in the Measurement of Acoustic Intensity Using the Cross-Spectral Method," SAE Trans. 90, pp 1520-1529 (1981).

99. Blaser, D.A. and Feldmaier, D.A., "Acoustic Intensity Measurements of Noise Emission from Engines," Engine Noise: Excitation, Vibration, and Radiation, pp 247-278, Plenum Press (1982).

100. Rasmussen, G. and Brock, M., "Acoustic Intensity Measurement Probe," Congress on Sound Intensity, Senlis, France (1981).

101. Roth, O., "A Sound Intensity Real-Time Analyzer," Congress on Sound Intensity, Senlis, France (1981).

102. Thompson, J.K. and Tree, D.R., "Finite Difference Approximation Errors in Acoustic Intensity Measurements," J. Sound Vib., 75, pp 229-238 (1981).

103. Elliot, S.J., "Errors in Acoustic Intensity Measurements," J. Sound Vib., 78, pp 439-444 (1981); reply by J.K. Thompson, pp 444-445.

104. Pope, J. and Chung, J.Y., Comments on "Finite Difference Approximation Errors in Acoustic Intensity Measurements," J. Sound Vib., 82, pp 459-462 (1982); reply by J.K. Thompson, pp 463-464.

105. Seybert, A.F., "Statistical Errors in Acoustical Intensity Measurements," J. Sound Vib., 75, pp 519-526 (1981).

106. McGary, M.C. and Crocker, M.J., "Surface Intensity Measurements on a Diesel Engine," Noise Control Engrg., 16, pp 26-36 (1981).

107. McGary, M.C. and Crocker, M.J., "Phase Shift Errors in the Theory and Practice of Surface Intensity Measurements," J. Sound Vib., 82, pp 275-288 (1982).

108. Crocker, M.J., "The Use of Existing and Advanced Intensity Techniques to Identify Noise Sources on a Diesel Engine," SAE Trans., 90, pp 2227-2238 (1981).

109. Crocker, M.J., "Comparison between Surface Intensity, Acoustic Intensity and Selective Wrapping Noise Measurements," Engine Noise: Excitation, Vibration, and Radiation, pp 279-312, Plenum Press (1982).

110. Abe, T. and Anderton, D., "Digital Acoustic Intensity Techniques in Gasoline Engine Noise Studies," SAE Prepr. 820363 (1982).

111. Halliwell, N.A. and Anderton, D., "Noise from Vibration," SAE Prepr. 800407 (1982).

112. Koopmann, G.H. and Benner, H., "Method for Computing the Sound Power of Machines Based on the Helmholtz Integral," J. Acoust. Soc. Amer., 71, pp 78-87 (1982).

113. Koopmann, G.H. and Benner, H., "A Method for Computing Surface Acoustic Intensities on Vibrating Structures," Engine Noise: Excitation, Vibration, and Radiation, pp 313-326, Plenum Press (1982).

LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains an article about dynamic applications of piezoelectric crystals.

Dr. M. Cengiz Dökmeci of Istanbul Technical University, Istanbul, Turkey, has written Part II of his review of current open literature pertaining to the dynamic applications of piezoelectric crystals. Representative theoretical and experimental papers cover waves and vibrations in piezoelectric one-dimensional and two-dimensional structural elements.

DYNAMIC APPLICATIONS OF PIEZOELECTRIC CRYSTALS
PART II: THEORETICAL STUDIES

M.C. Dökmeci*

Abstract. This paper presents a review of current open literature pertaining to the dynamic applications of piezoelectric crystals. Representative theoretical and experimental papers cover waves and vibrations in piezoelectric one-dimensional and two-dimensional structural elements. New trends of research are pointed out for future applications of piezoelectric crystals.

THEORETICAL STUDIES

The three-dimensional fundamental equations of piezoelectricity -- that is, the equations of elasticity (Newton's equations) and those of electricity (Maxwell's quasi-static equations) -- are coupled by piezoelectric material coefficients; the fundamental equations seldom have exact solutions. Piezoelectricity adds complexities in computation due to the presence of an electric field and anisotropy. Thus, a method of approximation is used either to solve the three-dimensional equations, to derive the lower order equations, or to both derive and solve one- and two-dimensional equations of piezoelectricity; the last is the most common case in open investigations.

Investigations up to 1979 involving elastic or acoustic waves, vibrations, flexure, and fracture in piezoelectric structural elements have been reviewed [56] and are thus excluded herein. Also excluded are studies dealing with statics and the inelastic behavior of piezoelectric elements as well as such special topics as energy trapping, waveguides, and acoustic emission. In this section analytical studies that cover piezoelectric bars, plates and disks, cylinders and spheres, layered elements, and surface waves are mentioned. Experimental representative studies involving piezoelectric structural elements are reviewed in Part III.

Bars. Bars and rods are one-dimensional structural elements in piezoelectric devices. Their low-frequency longitudinal vibrations have been of recent interest. The characteristics of the longitudinal vibrations of tapered piezoceramic bars, either polarized transversely or composite, have been calculated [64, 65]. Longitudinal vibrations have been also considered for a thin piezoceramic rod polarized along its thickness [66] and for a composite piezoceramic bar [67]. Frequency equations of piezoelectric composites in the one-dimensional approximation have been derived [68], and the forced transient motion and voltage response of a piezoelectric bar vibrating in a compressionally lengthwise mode have been studied [69]. A numerical solution for the electrical discharge of an axially polarized piezoceramic rod in shock loading has been found [70], and higher order, one-dimensional governing equations have been derived [71] for both low- and high-frequency vibrations of piezoelectric crystal bars.

Plates and disks. Considerable analytical and experimental efforts have been directed toward developing models and analyzing waves and vibrations in piezoelectric plates and disks. The plates are either uncoated, partially coated, or fully coated by perfectly conducting electrodes that are connected in a circuit. The most commonly encountered excitations are in modes of thickness-shear, thickness-twist, thickness-longitudinal, and coupled thickness-shear and flexure for piezoelectric plates and excitations in radial modes for piezoelectric disks. In both cases the excitations can be free or forced. Of work on the vibrations of piezoelectric plates, the excellent contributions of Mindlin, Tiersten, and co-workers are notable. Mindlin [50, 72] has derived the two-dimensional higher order governing equations that account for all types of vibrations of piezoelectric and thermopiezoelectric crystal plates within the framework of the three-dimensional theory of piezoelectricity.

*Istanbul Technical University, P.K. 9, Istanbul, Turkey

Tiersten [45] has thoroughly studied piezoelectric plates and provided some approximation techniques relevant to linear piezoelectric plate vibrations. Earlier studies involving piezoelectric plates have been examined in detail [45, 73].

Sinha and Stevens [74] considered the thickness-shear vibration modes of a beveled plate coated with electrodes and computed the resonant frequencies and modal shapes of the plate. They obtained good agreement with experimental results. The spectrum of natural frequencies for the transverse vibrations of a loaded piezoelectric plate with a transition layer has been determined [75]. The harmonic flexural modes of piezoelectric rectangular and circular plates with arbitrarily placed electrodes have been calculated under various boundary conditions [76]; the calculations were reasonably close to the experimental data. Other developments include work on the low-frequency vibrations of polycrystalline plates with or without electrode coatings [77] and on the longitudinal wave propagation of piezoelectric plates [78]. An analysis of reflection of a plane inhomogeneous wave from a reflective piezoelectric plate coated with metal electrodes on both sides has been made [79], and the radiation and reception of pulse signals by a piezoelectric plate have been examined [80]. The finite element method has been applied to the analysis of an axisymmetric composite piezoelectric plate for ultrasonic radiation [81].

The transient stress distributions and voltage developed in an annular disk of radially inhomogeneous piezoelectric material spinning with a variable angular velocity have been investigated [82]. Work has been published on the axisymmetric vibrations of a thin piezoceramic disk polarized along its thickness and with electrodes split on both faces [83]. The electrically excited radial vibrations of piezoceramic disks with arbitrarily arranged axisymmetrical electrodes and poling in the thickness and radial directions have been considered [84], as has a radially poled, annular piezoceramic disk the outer surface of which interacts with a surrounding acoustic medium [85]; the inner surface is stress free, and both surfaces are completely coated with electrodes. The electromechanical behavior and heat release associated with the electroelastic radial vibrations of the piezoceramic disk were also analyzed [85]. The flexural-extensional vibratory response of piezoelectric disks consisting of axially polarized layers has been described [86], and numerical results for the axially symmetric vibrations of a thick piezoceramic disk that is excited by full or partial electrodes on its faces have been reported [87].

Cylinders and spheres. Most investigations involving piezoelectric cylinders and spheres have been limited to the radial motions of spheres and to the radial, axial, and torsional motions of cylinders. Studies on radial motions include a hollow piezoceramic sphere [88], a piezoceramic sphere coated with electrodes on its surface in a compressible fluid [89], and a piezoceramic hollow sphere or cylinder filled with a compressible liquid and immersed within a fluid of infinite extent [90]. The numerical analysis of harmonic vibrations of a piezoceramic shell of revolution, coated with electrodes on its inner and outer surfaces, has been reported [91], as has the electroacoustic sensitivity of radially polarized ceramic cylinders as a function of frequency under both static and oscillating pressures [92]. Other investigations have dealt with the equations of motion for a piezoceramic cylinder having an inhomogeneous structure [93]; the vibration of a hollow, radially polarized, coated piezoceramic cylinder of finite size [94]; and the axisymmetric normal modes of a solid cylindrical piezoelectric waveguide [95]. The torsional wave motion of a finite inhomogeneous piezoelectric cylindrical shell has been investigated [96], as has that of a hollow piezoelectric cylinder [97] and that of a piezoelectric solid cylinder [98]. The acoustical characteristics of a baffled, radially polarized piezoelectric cylinder radiating through a liquid layer have been studied [99], as has shape-dependent damping in long cylinders, spheres, and even thin plates, whose materials exhibit piezoelectric relaxation [101], under dynamic loading [100].

Layered structural elements. Piezoelectric layered structural elements have become desirable in control engineering. Comprehensive state-of-the-art articles are available on the subject [31, 102], as is a two-dimensional higher order theory of vibrations of coated, thermopiezoelectric laminae [55, 56]. Investigations on layered structural elements have been concerned with the thickness-normal modes of a layered transducer in which a system of passive layers is interposed between the piezoelectric plate and the working medium [103]. Other studies have considered the pulse and transient responses of a

water-loaded layered piezoelectric plate [104]. A general procedure of reduction due to Mindlin [105] but using trigonometric expansions for field quantities has been used to deduce two-dimensional higher-order, approximate equations of piezoelectric layers from the three-dimensional equations of piezoelectricity [106, 107]. Some applications of the two-dimensional equations were illustrated for a few specific cases involving the motions of rectangular and circular layers [106, 107]. A mixed finite element-perturbation method was used to compute vibrational modes for a piezoelectric layered plate [108]. The pulsed transmit/receive response of a transducer consisting of a piezoceramic disk and several mechanical matching layers on both surfaces of the disk has been analyzed [109]. Wellekens [110, 111] recently derived analytical expressions for the mechanical vibrations of a piezoceramic disk-transducer having annular electrodes and matching layers.

Surface waves. Whenever acoustic waves propagate, two main types of waves -- longitudinal waves (compression waves) and transverse waves (fast and slow shear waves) -- can exist along the interface between two continua. One of the two continua is usually a piezoelectric substrate, and the other is air or another substrate. Rayleigh waves propagate at the free surface of a half-space continuum, Lamb waves propagate in thin layers, Stoneley waves propagate at a plane interface between two perfectly bonded, half-space continua, and Love waves propagate between the interface of a thin layer and a half-space continuum, as do Sezawa waves and leaky waves. In addition, Bleustein-Gulyaev waves, with no counterpart in a purely elastic continuum, arise at the free surface of a half-space piezoelectric continuum.

Both the electromechanical and geometrical structure of an elastic continuum significantly influence the types and characteristics of acoustic surface waves. A growing volume of research has been directed at acoustic surface waves during the last decade. Earlier works on the subject have been reviewed [56, 112, 113]. The subject and its applications have been elaborated [114-121].

Several authors have investigated the effects of homogeneous and inhomogeneous material properties, uniform and variable layer thicknesses, and plane and curved interfaces in, as well as the methods of excitation and reception of, acoustic surface waves. The influence of a flexural biasing state on the velocity of piezoelectric surface waves has been studied [122], as has piezoelectric surface wave scattering by periodic discontinuities using a perturbation approach [123]. The attenuation and velocity of surface waves on a piezoelectric substrate coated with admittance films have been considered [124], as have the propagation characteristics of surface acoustic waves in an initially strained piezoelectric continuum [125]. The propagation characteristics were compared to those of experimentally measured values; results were in close agreement [125]. The propagation characteristics of the Bleustein-Gulyaev waves in a periodically corrugated piezoelectric crystal have been examined theoretically and numerically [126]. Work has been done on the wave field associated with the excitation of a Bleustein-Gulyaev wave [127] and on the possibility of amplifying Stonely waves along the interface of a piezoelectric crystal and a dielectric crystal [128].

Other studies on surface waves have involved a thorough examination of the influence of the piezoelectric effect on the characteristics of transverse surface waves on cylindrical crystal surfaces [129, 130]. Gap waves, that is, wave modes capable of propagating along a very narrow space (gap) between piezoelectric halfspaces have been discussed [131]. The convolution of shear bulk waves and surface waves for a system of piezoelectric insulator, gap, and semiconductor has been studied [132], as have the attenuation of Lamb and shear horizontal waves in PVDF piezoelectric films [133] and the reflection and transmission of plane elastic waves for a piezoelectric ceramic in contact with water [134].

Studies of nonlinear piezoelectric effects include a theoretical analysis of the parametric excitation of the Bleustein-Gulyaev waves, transverse gap waves, and normal waves in a piezoelectric plate [135] and the generation of acoustic waves in crystals in the presence of reflection [136]. Other contributions are available on acoustic surface waves [137-141].

REFERENCES

1. Cady, W.G., Piezoelectricity, Vols 1 and 2, Dover Publications (1964).

2. Curie, P., Oeuvres de Pierre Curie, Gauthier-Villars & Cie (1908).

3. Voigt, W., Lehrbuch der Kristallphysik, Teubner (1910).

4. Mason, W.P., Piezoelectric Crystals and Their Applications to Ultrasonics, D. van Nostrand Co. (1950).

5. Zheludev, I.S., Physics of Crystalline Dielectrics, Vols 1 and 2, Plenum Press (1971).

6. Bergmann, L., Der Ultraschall und seine Anwendung in Wissenschaft und Technic, Hirzel (1954); Eng. Tr., Ultrasonics and Their Scientific and Technical Applications, John Wiley and Sons (1968).

7. Mason, W.P., "Piezoelectricity, Its History and Applications," J. Acoust. Soc. Amer., 70 (6), pp 1561-1566 (1981).

8. Nye, J.F., Physical Properties of Crystals, The Clarendon Press (1957).

9. Venkataraman, G., Feldkamp, L.A., and Sahni, V.C., Dynamics of Perfect Crystals, The M.I.T. Press (1975).

10. Shubnikov, A.V., Zheludev, I.S., Konstantinova, V.P., and Silvestrova, I.M., Issledovanie Piezoelektritcheskikh Textur, Izd-vo AN SSSR (1955); French Tr., Etude des Textures Piezoelectriques, Dunod (1958).

11. Jaffe, B., Cook, W.R., and Jaffe, H., Piezoelectric Ceramics, Academic Press (1971).

12. Kagawa, Y. and Hatakeyama, T., "Piezoelectric Effect in Liquid Crystals," J. Sound Vib., 53 (4), pp 585-593 (1977).

13. Bazhenov, V.A., Piezoelectric Properties of Wood, Consultants Bureau (1961).

14. Fukada, E., "Mechanical Deformation and Electrical Polarizstion in Biological Substances," Biorheology, 5 (1), pp 199-208 (1968).

15. Fukada, E., "Piezoelectricity in Polymers and Biological Substances," Ultrasonics, 6 (4), pp 229-234 (1968).

16. Deri, M., Ferroelectric Ceramics, Maclaren (1966).

17. Van Randeraat, J. (editor), Piezoelectric Ceramics, Philips Gloeilampenfabrienken (1968).

18. Berlincourt, D., "Piezoelectric Ceramics: Characteristics and Applications," J. Acoust. Soc. Amer., 70 (6), pp 1586-1595 (1981).

19. Sessler, G.M., "Piezoelectricity in Polyvinylidenefluoride," J. Acoust. Soc. Amer., 70 (6), pp 1596-1608 (1981).

20. Jona, F. and Shirane, G., Ferroelectric Crystals, Pergamon Press (1962).

21. Grindlay, J., An Introduction to the Phenomenological Theory of Ferroelectricity, Pergamon Press (1970).

22. Forsbergh Jr., P.W., "Piezoelectricity, Electrostriction and Ferroelectricity," Encyclopedia of Physics, Vol XVII: Dielectrics, pp 264-392, Springer-Verlag (1956).

23. Berlincourt, D.A., Curran, D.R., and Jaffe, H., Piezoelectric and Piezomagnetic Materials and Their Function in Transducers," Physical Acoustics, Vol 1 - Part 1, pp 169-270, Academic Press (1964).

24. Bechmann, R., Hearmon, R.F.S., and Kurtz, S.K., Elastic, Piezoelectric, Piezooptic and Electrooptic Constants of Crystals, Numerical Data and Functional Relationships in Science and Technology, Vol 1, Springer-Verlag (1966).

25. "IRE Standards on Piezoelectric Crystals, 1949," Proc. IRE, 37, pp 1378-1395 (1949).

26. "IRE Standards on Piezoelectric Crystals -- The Piezoelectric Vibrator: Definitions and Meth-

ods of Measurement, 1957," Proc. IRE, 45, pp 353-358 (1957).

27. "IRE Standards on Piezoelectric Crystals: Determination of the Elastic, Piezoelectric, and Dielectric Constants -- The Electromechanical Coupling Factor, 1958," Proc. IRE, 46, pp 764-778 (1958).

28. "IRE Standards on Piezoelectric Crystals: Measurements of Piezoelectric Ceramics, 1961," Proc. IRE, 49, pp 1161-1169 (1961).

29. Mason, W.P., Crystal Physics of Interaction Processes, Academic Press (1966).

30. Holland, R. and Eer Nisse, E.P., Design of Resonant Piezoelectric Devices, Res. Monog. No. 56, The M.I.T. Press (1969).

31. Nagy, N.F.L. and Joyce, G.C., "Solid State Control Elements Operating in Piezoelectric Principles," Physical Acoustics, Vol IX, pp 129-165, Academic Press (1972).

32. Domarkas, V.I. and Kazys, R.J., Kontrolesmatavimo Pjezoelektriniai Keitikliai (Russian), (Piezoelectric Transducers for Measuring Devices), Mintis (1975).

33. Keuning, D.H., "Approximate Equations for the Flexure of Thin, Incomplete, Piezoelectric Bimorphs," J. Engrg. Math., 5 (4), pp 307-319 (1971).

34. Mindlin, R.D., "Torsion and Flexure of Piezoelectric Crystal Bars," Application of Elastic Waves in Electrical Devices, Non-Destructive Testing, and Seismology, pp 83-99, NSF Engrg. Mech. Sec., Solid Mech. Prog. (1976).

35. Parton, V.Z., "Fracture Mechanics of Piezoelectric Materials," Acta Astronautica, 3 (9/10), pp 671-683 (1976).

36. Kosmodamianskii, A.S., Kravchenko, A.P., and Lozhkin, V.N., "Electroelastic State of a Piezoelectric Half Plane with Elliptical Core," Sov. Appl. Mech., 14 (10), pp 1073-1078 (1978); Prikl. Mekh., 14 (10), pp 75-81.

37. Ricketts, D., "Model for a Piezoelectric Polymer Flexural Plate Hydrophone," J. Acoust. Soc. Amer., 70 (4), pp 929-935 (1981).

38. Landau, L.D. and Lifshitz, E.M., Electrodynamics of Continuous Media, Addison-Wesley (1960).

39. Truesdell, C. and Toupin, R., "Classical Field Theories," Encyclopedia of Physics, Vol III/1: Principles of Classical Mechanics and Field Theory, pp 226-793, Springer-Verlag (1960).

40. Tamm, I.E., Principles of the Theory of Electricity, Fizmatgiz (1965).

41. Stratton, J.A., Electromagnetic Theory, McGraw-Hill (1941).

42. Parkus, H., (editor), Electromagnetic Interactions in Solids, Springer-Verlag (1979).

43. Tiersten, H.F., "The Radiation and Confinement of Electromagnetic Energy Accompanying the Oscillations of Piezoelectric Crystal Plates," Recent Advances in Engineering Science, Vol V, Part I, pp 63-90, Gordon and Breach (1970).

44. Mindlin, R.D., "On the Equations of Motion of Piezoelectric Crystals," Problems of Continuum Mechanics, pp 282-290, SIAM (1961).

45. Tiersten, H.F., Linear Piezoelectric Plate Vibrations, Plenum Press (1969).

46. Nowacki, W., "Foundations of Linear Piezoelectricity," Electromagnetic Interactions in Solids, pp 105-157, Springer-Verlag (1979).

47. Thurston, R.N., "Waves in Solids," Encyclopedia of Physics, Vol VIa/4, Mechanics of Solids, pp 109-308, Springer-Verlag (1974).

48. Nelson, D.F., "Theory of Nonlinear Electoacoustics of Dielectric, Piezoelectric, and Pyroelectric Crystals," J. Acoust. Soc. Amer., 63 (6), pp 1738-1748 (1978).

49. Gagnepain, J.J. and Besson, R., "Nonlinear Effects in Piezoelectric Quartz Crystals,"

Physical Acoustics, Vol X1, pp 245-288, Academic Press (1975).

50. Mindlin, R.D., "Equations of High Frequency Vibrations of Thermopiezoelectric Crystal Plates," Intl. J. Solids Struc., 10, pp 625-637 (1974).

51. Nowacki, W., "Some General Theorems of Thermopiezoelectricity," J. Thermal Stresses, 1 (2), pp 171-182 (1978).

52. Lothe, J. and Barnett, D.M., "On the Existence of Surface Wave Solutions in Piezoelectric Crystals, An Example of Non-existence," Wave Motion, 1 (1), pp 107-112 (1979).

53. Mindlin, R.D., Theory of Beams and Plates, Lecture notes at Columbia University (1956).

54. Gubenkov, A.N., Kirichenko, V.F., Kulikov, E.L., and Pavlov, S.P., "A Variational Principle for Problems in the Analysis of Piezoelectric Devices with Acoustoelectric Coupling," Sov. Phys. Acoust., 24 (2), pp 111-114 (1978); Akust. Zh., 24, pp 195-202.

55. Dokmeci, M.C., "Theory of Vibrations of Coated, Thermopiezoelectric Laminae," J. Math. Phys., 19 (1), pp 109-126 (1978).

56. Dökmeci, M.C., "Recent Advances: Theory of Vibrations of Piezoelectric Crystals," Intl. J. Engrg. Sci., 18 (3), pp 431-448 (1980).

57. Dökmeci, M.C., "Variational Principles for Linear Piezoelectricity," L. Al Nuovo Cimento, 7 (11), pp 449-454 (1973).

58. Tiersten, H.F., "Natural Boundary and Initial Conditions from a Modification of Hamilton's Principle," J. Math. Phys., 9 (9), pp 1445-1451 (1968).

59. Kudriavtsev, B.A., Parton, V.Z., and Rakitin, V.I., "Fracture Mechanics of Piezoelectric Materials. Axisymmetric Crack on the Boundary with a Conductor," Sov. Appl. Math. Mech., 39 (2), pp 328-338 (1975); PMM, 39, pp 352-362.

60. Carlson, D.E., "Linear Thermoelasticity," Encyclopedia of Physics, Vol VIa/2, Mechanics of Solids, pp 297-345, Springer-Verlag (1972).

61. Müller, L., "The Reciprocal Theorem for Piezoelectrics as Interpreted by R.D. Mindlin," Bull. Acad. Polonaise Sci., Ser. Sci. Techn., 28 (1/2), pp 27-32 (1980).

62. Brzezinski, A., "Reciprocal Theorem for Piezoelectric Thermoelasticity," Bull. Acad. Polonaise Sci., Ser. Sci. Techn., 26 (2), pp 143-150 (1978).

63. Tanaka, K. and Tanaka, M., "A Boundary Element Formulation in Linear Piezoelectric Problems," Z. angew Math. Phys., 31 (5), pp 568-580 (1980).

64. Alekseev, B.N., Dianov, D.B., and Karuzo, S.P., "Tapered Piezoelectric Bar Transducer with Transverse Polarization of the Piezoceramic," Sov. Phys. Acoust., 23 (1), pp 1-4; Akust. Zh., 23, pp 1-8 (1977).

65. Alekseev, B.N., Dianov, B.N., and Karuzo, S.P., "Composite Tapered Piezoceramic Bar Transducer," Sov. Phys. Acoust., 24 (2), pp 98-101; Akust. Zh., 24, pp 168-173 (1978).

66. Bondarenko, A.A., Kutsenko, G.V., and Ulitko, A.F., "Amplitudes and Phases of Longitudinal Vibrations of Piezoceramic Rods with Account of Variable Mechanical Quality Factor," Sov. Appl. Mech., 16 (11), pp 1001-1004 (1981), Prikl. Mekh., 16 (11), pp 84-88.

67. Busher, M.K. and Syrkin, L.N., "Application of the Reissner Mixed Variational Principle from the Theory of Elasticity for the Calculation of Inhomogeneous Piezoceramic Bar Transducers," Sov. Phys. Acoust., 24 (5), pp 374-378 (1979); Akust. Zh., 24, pp 664-672.

68. Cherpak, V.A., "Dynamic Lumped Parameters of Composite Piezoelectric Transducers," Sov. Phys. Acoust., 23 (3), pp 246-250 (1977); Akust. Zh., 23, pp 443-449.

69. Das, A. and Ray, A., "Forced Transient Motion of a Piezoelectric Bar and Its Voltage Re-

sponse," Indian J. Tech., 18, pp 349-353 (1980).

70. Zharii, O.Yu., "Discharge of a Piezoceramic Rod in Shock Loading," Sov. Appl. Mech., 17 (3), pp 284-288 (1981); Prikl. Mekh., 17 (3), pp 98-103.

71. Dokmeci, M.C., "A Theory of High Frequency Vibrations of Piezoelectric Crystal Bars," Intl. J. Solids Struc., 10 (4), pp 401-409 (1974).

72. Mindlin, R.D., "High Frequency Vibrations of Piezoelectric Crystal Plates," Intl. J. Solids Struc., 8, pp 895-906 (1972).

73. Lee, P.C.Y. and Haines, D.W., "Piezoelectric Crystals and Electro-Elasticity," R.D. Mindlin and Applied Mechanics, pp 227-253, Pergamon Press (1974).

74. Sinha, B.K. and Stevens, D.S., "Thickness-shear Vibrations of a Beveled AT-cut Quartz Plate," J. Acoust. Soc. Amer., 66 (1), pp 192-196 (1979).

75. Kasatkin, B.A. and Lebedev, V.G., "Spectrum of Natural Frequencies of a Loaded Piezoelectric Plate with a Transition Layer," Sov. Phys. Acoust., 25 (3), pp 224-227 (1979); Akust. Zh., 25, pp 395-400.

76. Aronov, B.S. and Nikitin, L.B., "Calculation of the Flexural Modes of Piezoceramic Plates," Sov. Phys. Acoust., 27 (5), pp 382-387 (1982); Akust. Zh., 27, pp 687-696.

77. Lozhkin, V.N., "Low-frequency Vibrations of Piezocrystalline Plates," Sov. Appl. Mech., 17, pp 673-677 (1982); Prikl. Mekh., 17, pp 89-93.

78. Schwarz, R., "Dreidimensionales Modell einer quaderformigen Piezokeramik fur longitudinale Wellenausbreitung," Acustica, 47 (4), pp 275-282 (1981).

79. Shnitser, P.I., "Analysis of Oscillations in an Open Acoustic Resonator with Reflective Piezoelectric Transducers," Sov. Phys. Acoust., 26 (3), pp 244-247 (1980); Akust. Zh., 26, pp 446-452.

80. Gitis, M.B. and Shenker, A.A., "Pulsed Operation of a Flat Piezoelectric Transducer," Sov. Phys. Acoust., 27 (6), pp 469-472 (1982); Akust. Zh., 27, pp 848-854.

81. Kagawa, Y. and Yamabuchi, T., "Finite Element Simulation of a Composite Piezoelectric Ultrasonic Transcucer," IEEE SU-26 (2), pp 81-88 (1979).

82. Das, A. and Ray, A., "Transient Stresses and Voltage Developed in a Spinning Disc of Radially Inhomogeneous Piezoelectric Material," J. Sound Vib., 67 (1), pp 75-87 (1979).

83. Vovkodav, I.F., Karlash, V.L., and Ulitko, A.F., "Axisymmetric Vibrations of Thin Piezoceramic Disks with Split Electrodes," Sov. Appl. Mech., 15 (2), pp 148-152 (1979); Prikl. Mekh., 15, pp 77-82.

84. Aronov, B.S., "Calculation of the Radial Modes of Piezoceramic Disks with Axisymmetrical Electrodes," Sov. Appl. Mech., 16 (11), pp 986-992 (1981); Prikl. Mekh., 16, pp 65-72.

85. Kirichok, I.F., "Heat Release Associated with the Electroelastic Modes of Piezoelectric Ceramic Disks," Sov. Appl. Mech., 16 (10), pp 902-905 (1981); Prikl. Mekh., 16, pp 82-86.

86. Adelman, N.T. and Stavsky, Y., "Flexural-extensional Behavior of Composite Piezoelectric Circular Plates," J. Acoust. Soc. Amer., 67 (3), pp 819-822 (1980).

87. Schwarzenbach, H.U., Lechner, H., Steinle, B., Baltes, H.P. and Schwendmann, P., "Calculation of Vibrations of Thick Piezoceramic Disk Resonators," Appl. Phys. Lett., 38 (11), pp 854-855 (1981).

88. Barilov, E.S., Vassergiser, M.E., and Dorosh, A.G., "Calculation of Equivalent-Circuit Parameters for a Radially Polarized Piezoceramic Sphere," Sov. Phys. Acoust., 25 (3), pp 199-202 (1979); Akust. Zh., 25, pp 352-357.

89. Borisyuk, A.I. and Kirichok, I.F., "Steady-State Radial Vibrations of Piezoceramic Spheres in Compressible Fluid," Sov. Appl. Mech.,

15 (10), pp 936-940 (1980); Prikl. Mekh., 15 (10), pp 45-49.

90. Kirichok, I.F., "Numerical Solution of Problems of the Electroelastic Oscillation of a Cylinder and a Sphere," Sov. Appl. Mech., 16 (2), pp 121-125 (1980); Prikl. Mekh., 16 (2), pp 45-50.

91. Gololobov, V.I., "Numerical Analysis of Piezoelectric Ceramic Shells of Revolution," Sov. Appl. Mech., 17 (4), pp 339-343 (1981); Prikl. Mekh., 17 (4), pp 38-42.

92. Burt, J.A., "The Electroacoustic Sensitivity of Radially Polarized Ceramic Cylinders as a Function of Frequency," J. Acoust. Soc. Amer., 64 (6), pp 1640-1644 (1978).

93. Busher, M.K., "Dynamic Equations for a Piezoceramic Radiating Transducer Having an Inhomogeneous Structure," Sov. Phys. Acoust., 24 (6), pp 476-479 (1979); Akust. Zh., 24, pp 835-843.

94. Abdulgalimov, A.M., "Vibration of Cylindrical Piezocoverters of Finite Size," Moscow Univ. Mech. Bull., 36 (2), pp 38-42 (1981); Vestnik Moskovskogo Univ. Mekh., 36 (2), pp 71-76.

95. Kasatkin, B.A., "Generalized Orthogonality Relations for the Normal Modes of a Piezoelectric Waveguide and Their Application in the Theory of Resonators," Sov. Phys. Acoust., 27 (4), pp 290-292 (1982); Akust. Zh., 27, pp 520-525.

96. Sarma, K.V., "Torsional Wave Motion of a Finite Inhomogeneous Piezoelectric Cylindrical Shell," Intl. J. Engrg. Sci., 18, pp 449-454 (1980).

97. Srinivasamoorthy, V.R. and Anandam, C., "Torsional Wave Propagation in an Infinite Piezoelectric Cylinder (622) Crystal Class," J. Acoust. Soc. Amer., 67 (6), pp 2034-2035 (1980).

98. Paul, H.S. and Raju, D.P., "Asymptotic Analysis of the Torsional Modes of Wave Propagation in a Piezoelectric Solid Circular Cylinder of (622) Class," Intl. J. Engrg. Sci., 19, pp 1069-1076 (1981).

99. Dianov, D.B., Zadirienko, I.M., and Kuz'menko, A.G., "Acoustical Characteristics of a Baffled Cylindrical Piezoelectric Transducer Radiating through a Liquid Layer," Sov. Phys. Acoust., 27 (3), pp 197-199 (1981); Akust. Zh., 27, pp 358-362.

100. Lakes, R., "Shape-Dependent Damping in Piezoelectric Solids," IEEE SU-27 (4), pp 208-213 (1980).

101. Martin, G.E., "Dielectric, Piezoelectric, and Elastic Losses in Longitudinally Polarized Segmented Ceramic Tubes," U.S. Navy J. Underwater Acoust., 15, pp 329-332 (1965).

102. Sittig, E.K., "Design and Technology of Piezoelectric Transducers for Frequencies above 100 MHz," Physical Acoustics, Vol. IX, pp 221-275, Academic Press (1972).

103. Kasatkin, B.A., "Generalized Orthogonality of Normal Modes of Layered Piezoelectric Transducers," Sov. Phys. Acoust., 25 (5), pp 402-405 (1980); Akust., Zh., 25, pp 710-716.

104. Kasatkin, B.A., "Pulse and Transient Responses of a Water-Loaded Layered Piezoelectric Transducer," Sov. Phys. Acoust., 27 (1), pp 85-86 (1981); Akust. Zh., 27, pp 153-155.

105. Mindlin, R.D., An Introduction to the Mathematical Theory of Vibrations of Elastic Plates, U.S. Army Signal Corps Engrg. Lab., Fort Monmouth (1955).

106. Bugdayci, N. and Bogy, D.B., "A Two-Dimensional Theory for Piezoelectric Layers Used in Electro-mechanical Transducers - I: Derivation and II: Applications," Intl. J. Solids Struc., 17 (12), pp 1159-1178 and 1179-1202 (1981).

107. Bugdayci, N. and Bogy, D.B., "A Two-Dimensional Theory for Piezoelectric Layers Used in Electro-mechanical Transducers - II: Applications," Intl. J. Solids Struc., 17 (12), pp 1179-1202 (1981).

108. Boucher, D., Lagier, M., and Maerfeld, C., "Computation of the Vibrational Modes for Piezoelectric Array Transducers Using a Mixed Finite Element-Perturbation Method," IEEE SU-28 (5), pp 318-330 (1981).

109. Stepanishen, P.R., "Pulsed Transmit/Receive Response of Ultrasonic Piezoelectric Transducers," J. Acoust. Soc. Amer., 69 (6), pp 1815-1827 (1981).

110. Wellekens, C.J., "Vibrations of Backed Piezoceramic Disk-Transducers with Annular Electrodes and Matching Layers - Part I," IEEE SU-29 (1), pp 26-37 (1982).

111. Wellekens, C.J., "Vibrations of Backed Piezoceramic Disk-Transducers with Annular Electrodes and Matching Layers - Part II," IEEE SU-29 (1), pp 37-42 (1982).

112. White, R.M., "Surface Elastic Waves," Proc. IEEE, 58, pp 1238-1276 (1970).

113. Viktorov, I.A., "Types of Acoustic Surface Waves in Solids (Review)," Sov. Phys. Acoust., 25 (1), pp 1-9 (1979); Akust. Zh., 25, pp 1-17.

114. Auld, B.A., Acoustic Fields and Waves in Solids, Vols. 1 and 2, John Wiley and Sons (1973).

115. Dieulesaint, E. and Royer, D., Elastic Waves in Solids, John Wiley and Sons (1980).

116. Farnell, G.W., "Types and Properties of Surface Waves," Acoustic Surface Waves, pp 13-60, Springer-Verlag (1978).

117. Gerard, H.M., "Principles of Surface Wave Filter Design," Acoustic Surface Waves, pp 61-96, Springer-Verlag (1978).

118. Ash, E.A., "Fundamentals of Signal processing Devices," Acoustic Surface Waves, pp 97-185, Springer-Verlag (1978).

119. Oliner, A.A., "Waveguides for Surface Waves," Acoustic Surface Waves, pp 187-223, Springer-Verlag (1978).

120. Slobodnik, Jr., A.J., "Materials and Their Influence on Performance," Acoustic Surface Waves, pp 225-303, Springer-Verlag (1978).

121. Smith, H.I., "Fabrication Techniques for Surface Wave Devices," Acoustic Surface Waves, pp 305-324, Springer-Verlag (1978).

122. Sinha, B.K. and Tiersten, H.F., "On the Influence of a Flexural Biasing State on the Velocity of Piezoelectric Surface Waves," Wave Motion, 1 (1), pp 37-51 (1979).

123. Datta, S., Theory of Guided Acoustic Waves in Piezoelectric Solids, Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign (1979).

124. Shimizu, Y. and Terazaki, A., "Attenuation and Velocity of Surface Waves on a Piezoelectric Substrate Coated with Admittance Films," J. Acoust. Soc. Amer., 66 (3), pp 806-810 (1979).

125. Nalamwar, A.L. and Epstein, M., "Surface Acoustic Waves in Strained Media," J Appl. Phys., 47 (1), pp 43-48 (1976).

126. Tsutsumi, M. and Kumagai, N., "Behavior of Bleustein-Gulyaev Waves in a Periodically Corrugated Piezoelectric Crystal," IEEE MTT-28 (6), pp 627-632 (1980).

127. Pyatakov, P.A., "Structure of the Wave Field Associated with Excitation of a Gulyaev-Bleustein Wave," Sov. Phys. Acoust., 24 (3), pp 218-221 (1978); Akust. Zh., 24, pp 394-400.

128. Morocha, A.K., Ovsyannikova, O.B., and Shermergor, T.D., "Amplification of Stonely Waves at an Interface between a Piezoelectric Semiconductor and a Dielectric Crystal," Sov. Phys. Acoust., 24 (3), pp 212-214 (1978); Akust. Zh., 24, pp 383-387.

129. Viktorov, I.A. and Pyatakov, P.A., "Acoustoelectric Interactions on Cylindrical Surfaces of Piezoelectric Semiconductors," Sov. Phys. Acoust., 25 (2), pp 159-161 (1979); Akust. Zh., 25, pp 290-293.

130. Viktorov, I.A. and Pyatakov, P.A., "Influence of the Piezoelectric Effect on the Properties of Transverse Surface Waves on Cylindrical Surfaces of Crystals," Sov. Phys. Acoust., 24 (1), pp 28-30 (1978); Akust. Zh., 24, pp 53-58.

131. Gulyaev, Yu.V. and Plesskii, V.P., "Acoustic Gap Waves in Piezoelectric Materials," Sov. Phys. Acoust., 23 (5), pp 410-413 (1978); Akust. Zh., 23, pp 716-723.

132. Mozhaev, V.G., "Shear-Wave Convolution in a Layered Piezoelectric-Semiconductor Structure," Sov. Phys. Acoust., 27 (2), pp 156-159 (1981); Akust. Zh., 27, pp 285-290.

133. Horvat, P. and Auld, B.A., "Attenuation des Ondes de Cisaillement Horizontal et des Ondes de Lamb dans les Films Piézoélectriques de Poly (fluorure de vinylidène)," C.R. Acad. Sci., 290, Série B, pp 333-336 (1980).

134. Noorbehesht, B. and Wade, G., "Reflection and Transmission of Plane Elastic Waves at the Boundary between Piezoelectric Materials and Water," J. Acoust. Soc. Amer., 67 (6), pp 1947-1953 (1980).

135. Burlak, G.N., Kotsarenko, N., Ya., and Pustyl'nik, T.N., "Parametric Excitation of Acoustic Waves in Bounded Piezoelectrics," Sov. Phys. Acoust., 22 (6), pp 1059-1061 (1980); Akust. Zh., 22, pp 1825-1828.

136. Burlak, G.N. and Kotsarenko, N.Ya., "Generation of Acoustic Waves in Crystals with the Nonlinear Piezoelectric Effect in the Presence of Reflection," Sov. Phys. Acoust., 27 (1), pp 81-83 (1981); Akust. Zh., 27, pp 148-150.

137. Taylor, D.B. and Crampin, S., "Surface Waves in Anisotropic Media: Propagation in a Homogeneous Piezoelectric Halfspace," Proc. Royal Soc. London, Ser. A 364, pp 161-179 (1978).

138. Mozhaev, V.G. and Solodov, I. Yu, "Second-Harmonic Generation of Acoustic Surface Waves in a Layered Piezoelectric Insulator-Semiconductor Structure," Sov. Phys. Acoust., 26 (3), pp 236-240 (1980); Akust. Zh., 26, pp 433-439.

139. Tiersten, H.F., Sinha, B.K., and Meeker, T.R., "Intrinsic Stress in Thin Films Deposited on Anisotropic Substrates and Its Influence on the Natural Frequencies of Piezoelectric Resonators," J. Appl. Phys., 52 (9), pp 5614-5624 (1981).

140. Pouget, J. and Maugin, G.A., "Piezoelectric Rayleigh Waves in Elastic Ferroelectrics," J. Acoust. Soc. Amer., 69 (5), pp 1319-1325 (1981).

141. Kazhis, R.I., "Frequency Responses of a Piezoelectric Shear-Mode Receiver with an Inhomogeneous Electric Field," Sov. Phys. Acoust., 26 (1), pp 39-43 (1980); Akust. Zh., 26, pp 74-83.

142. Korobov, A.I. and Lyamov, V.E., "Nonlinear Piezoelectric Coefficients of $LiNbO_3$," Sov. Phys. Solid State, 17 (5), pp 932-933 (1975); Fiz. Tverd. Tela., 17, pp 1448-1450.

143. Nakagawa, Y., Yamanouchi, K., and Shibayama, K., "Third-Order Elastic Constants of Lithium Niobate," J. Appl. Phys., 44 (9), pp 3969-3974 (1973).

144. Bell, J.F., "The Experimental Foundations of Solid Mechanics," Encyclopedia of Physics, Vol. VIa/1; Mechanics of Solids I, pp 1-813, Springer-Verlag (1973).

145. GOST (All-Union State Standard) 12370-72: Piezoceramic Materials. Testing Methods (in Russian), Izd. Standartov, Moscow (1973).

146. Baryshnikova, L.F. and Lyamov, V.E., "Elliptical Polarization of Acoustic Waves in Piezoelectric Crystals under the Action of an Electric Field," Sov. Phys. Acoust., 26 (6), pp 465-467 (1981); Akust. Zh., 26, pp 824-827.

147. Lerch, R. and Sessler, G.M., "Microphones with Rigidly Supported Piezopolymer Membranes," J. Acoust. Soc. Amer., 67 (4), pp 1379-1381 (1980).

148. Rosenberg, A. and Politch, J., "Investigation of of a Vibrating Piezoelectric Ceramic Disk by Synthesis of Optical Coherent Methods," Exptl. Mech., 20 (4), pp 140-144 (1980).

149. Ito, Y., Nagatsuma, K., Takeuchi, H., and Jyomura, S., "Surface Acoustic Wave and Piezoelectric Properties of (Pb, Ln) (Ti, Mn)O_3 Ceramics (Ln = rare earth)," J. Appl. Phys., 52 (7), pp 4479-4486 (1981).

150. Takeuchi, H. and Yamauchi, H., "Strain Effects on Surface Acoustic Wave Velocities in Modified $PbTiO_3$ Ceramics," J. Appl. Phys., 52 (10), pp 6147-6150 (1981).

151. Tanaka, H., Shimizu, H., and Yamada, K., "Methods for Energy Trapping of Thickness Extensional Mode and Thickness Shear Mode in Piezoelectric Ceramic Plate," Elec. Comm. Japan, 62-A (8), pp 10-19 (1981).

152. Tsok, O.E., "Influence of the Dimensions of Piezoelectric Plates on the Nature of Their Vibrational Modes," Sov. Phys. Acoust., 26 (6), pp 524-525 (1981); Akust. Zh., 26, pp 929-931.

153. Magdich, L.N. and Shnitser, P.I., "Structure of the Oscillations in an Open Acoustic Resonator with a Reflective Piezoelectric Transducer," Sov. Phys. Acoust., 27 (4), pp 313-315 (1982); Akust. Zh., 27, pp 562-566.

154. Lanina, E.P., "Tunable High-Frequency High-Power Piezoceramic Radiator," Sov. Phys. Acoust., 24 (3), pp 207-209 (1978); Akust. Zh., 24, pp 372-375.

155. Pajewski, W., "Transversal Bleustein-Gulayev (B.G.) Surface Waves on a Piezoelectric Ceramic," Arch. Acoust., 2 (3), pp 197-206 (1977).

156. Kinh, N.V. and Pajewski, W., "Generation of Acousto-electrical Waves Using a Source of Transverse Vibrations," Arch. Acoust., 5 (3), pp 261-274 (1980).

157. Karlash, V.L., Klyushnichenko, V.A., Kramarov, Yu.A., and Ulitko, A.F., "Radial Vibrations of Thin Piezoceramic Disks under a Nonuniform Electric Load," Sov. Appl. Mech., 13 (8), pp 784-788 (1977); Prikl. Mekh., 13, pp 56-62.

158. Karlash, V.L., "Radial Modes of Piezoceramic Disks with Open-Circuit Electrodes," Sov. Appl. Mech., 17 (9), pp 836-839 (1982); Prikl. Mekh., 17, pp 83-87.

159. Karlash, V.L., "Nonsymmetric Vibrations of Piezoelectric Ceramic Rings Polarized along the Thickness," Sov. Appl. Mech., 14 (12), pp 1303-1308 (1979); Prikl. Mekh., 14, pp 88-94.

160. Golanowski, J. and Gudra, T., "Ultrasonic Transducers Using Radial Vibrations of a Piezoelectric Disk," Arch. Acoust., 4 (3), pp 245-255 (1979).

161. Bogy, D.B. and Miu, D.K.K., "Transient Voltage across Axisymmetrically Loaded Piezoelectric Disks with Electroded Faces," J. Acoust. Soc. Amer., 71 (2), pp 487-497 (1982).

162. Burt, J.A., "The Response of a Fluid-filled Piezoceramic Cylinder to Pressure Generated by an Axial Laser Pulse," J. Acoust. Soc. Amer., 65 (5), pp 1164-1169 (1979).

163. Ricketts, D., Electroacoustic Sensitivity of Composite Piezoelectric Polymer Cylinders," J. Acoust. Soc. Amer., 68 (4), pp 1025-1029 (1980).

164. Tims, A.C., "Effects of Multidimensional Stress on Radially Polarized Piezoelectric Ceramic Tubes," J. Acoust. Soc. Amer., 70 (1), pp 21-28 (1981).

165. Lerch, R., "Electroacoustic Transducers Using Piezoelectric Polyvinylidenefluoride Films," J. Acoust. Soc. Amer., 66 (4), pp 952-954 (1979).

166. Lerch, R., "Piezopolymer Transducers with Point-Supported Membranes," J. Acoust. Soc. Amer., 70 (5), pp 1229-1234 (1981).

167. Sheiko, Yu.A., "Equivalent Circuit of a Flexurally Vibrating Multielectrode Piezoelectric Bar," Sov. Phys. Acoust., 24 (2), pp 154-156 (1978); Akust. Zh., 24, pp 279-283.

168. McNab, A. and Richter, J., "Electromagnetic Field Reciprocity Applied to the Excitation and Detection of Elastic Waves in an Electromagnetic Cavity Resonator," J. Acoust. Soc. Amer., 66 (6), pp 1593-1600 (1979).

169. Horvat, P. and Auld, B.A., "Propagation d'ondes de Cisaillement et d'ondes de Lamb dans les Films Piézoélectriques de Poly(fluorure de vinylidène)," C.R. Acad. Sci., 290, Série B, pp 1-4 (1980).

170. Tiersten, H.F., McDonald, J.F., Tse, M.F., and Das, P., "Monolithic Mosaic Transducer Utilizing Trapped Energy Modes," Acoustical Holography, Vol. 7, pp 405-422, Plenum Publ. Corp. (1977).

171. Tiersten, H.F., Sinha, B.K., McDonald, J.F., and Das, P.K., "On the Influence of a Tuning Inductor on the Bandwidth of Extensional Trapped Energy Mode Transducers," IEEE Ultrasonics Symp. Proc., pp 163-166 (1978).

172. Lee, D.L., "Analysis of Energy Trapping Effects for SH-Type Waves on Rotated Y-Cut Quartz," IEEE SU-28 (5), pp 330-341 (1981).

173. Watanabe, H., Nakamura, K., and Shimizu, H., "A New Type of Energy Trapping Caused by Contributions from the Complex Branches of Dispersion Curves," IEEE SU-28 (4), pp 265-270 (1981).

BOOK REVIEWS

STRUCTURAL MECHANICS SOFTWARE SERIES IV

N. Perrone and W. Pilkey, Editors
University Press of Virginia, Charlottesville, VA
1982, 467 pp

The format of this fourth volume of the series is similar to the previous ones in that reviews of programs and technologies in structural mechanics are presented, as are sources of information and programs in the subject area. In this volume, four of the thirteen reviews are related to problems in train dynamics; topics of the other nine reviews vary widely.

The first section of the book deals with sources of information and programs. The authors describe three major commercial services that offer interactive access to more than 80 data bases. Of these data bases, four are noted whose maintainers will perform personalized customer searches. Also listed are 24 program dissemination centers and user groups from which programs and program information can be obtained.

The major section of the book contains reviews and summaries of available programs as follows:

1) A brief description of the plastic analysis programs ADINA, AGGIE I, ANSYS, ASKA, ASAS, BERSAFE, EPACA, MARC, NEPSAP, PAFEC 75, PLANS, and WECAN. Included as an introduction is a good review of assumptions and models for plastic behavior -- e.g., yield criteria, loading surfaces, hardening criteria -- as well as a review of solution procedures.

2) A brief description of the characteristics of 42 fracture mechanics programs.

3) An excellent, in-depth, comprehensive review of COSMIC/NASTRAN, including program architecture, functional description, element evaluations, and documentation.

4) Brief reviews of a number of programs for reinforced concrete structures.

5) A review of the types of computers, from micros to super mainframes, on which structural mechanics software exists and some predictions of future trends of such hardware architecture.

6) An extensive comparison of the capabilities of PAFEC and other finite element codes.

7) Discussions and reviews of programs associated with longitudinal, vertical, and lateral train dynamics, including curving dynamics and lateral stability.

The third and final section of the book contains excellent, in-depth reviews of four areas of computational mechanics technology. The first paper describes a framework for evaluating structural mechanics software. That framework includes both an external evaluation performed by an independent third party (neither the developer nor a dedicated user) and an internal evaluation of the solution of a specific problem performed by the program itself. This would include various adaptive strategies such as time stepping and mesh refinement.

The second paper of the final section describes such integration methods for stiff systems as those usually encountered in structural dynamics. Stability, accuracy, and efficiency are considered for a number of integration methods including Newmark Beta, Runge-Kutta, and some of their variants. The paper also covers aspects of adaptive time step procedures.

The third paper briefly discusses and assesses computer programs used in analytical evaluations of freight car trucks in the areas of lateral stability, curving dynamics, ride quality, and trackability. These programs were selected as applicable to the Federal Railroad Administration's Truck Design Optimization Project.

The final paper contains an in-depth, comprehensive review of static reanalysis methods. Such methods

are of use in design-analysis cycles in which direct solutions of new designs could be avoided, due to excessive cost, by using information obtained from the solution of an initial design. Both exact and approximate methods are discussed. Exact methods lead to exact expressions for the inverse or triangular factors of modified stiffness matrices and use the inverse or factors of an initial stiffness matrix. Operation counts for a number of methods, including direct solution, are computed. Approximate methods covered in detail are truncated Taylor series, reduced basis, and iterative techniques. Because these methods produce approximate results, both accuracy and efficiency are discussed.

Because the book is composed of papers written by twenty authors and contains much tabulated information, comments related to writing style or format would not be meaningful. However, two aspects of the editing process should be mentioned. A significant number of typographical errors were not caught, and corrections were made in a type different from the original text. Despite these minor problems, the book is so full of varied information that almost everyone involved in computational structural mechanics will be able to gain some useful knowledge for his or her work.

M.M. Hurwitz
Numerical Structure Mechanics
Branch (Code 1844)
Computation, Mathematics and
Logistics Department
David Taylor Naval Ship R&D Center
Bethesda, Maryland 20084

THE DYNAMICS OF ARCHES AND FRAMES

J. Henrych
Elsevier Scientific Publishing Co.
Amsterdan, The Netherlands and New York, NY
1981, 350 pp, $93.00

This book deals with the analysis of dynamically loaded arches and frames with straight and curved elements of constant and variable cross sections. The excitations consist of time-dependent forces and prescribed motions at specific points of the structure.

Chapters 2-5 are concerned with the dynamics of arches: In Chapter 2 the equations of motion (continuum models) of arches with arbitrary shapes and variable cross sections are derived; included are the effects of extensible centroidal axes, shear deformation, rotary inertia, and damping. The equations of motion are specialized for circular arches with constant cross sections, and the free vibration problem is discussed. Chapter 3 deals with the forced vibration of arches by harmonic analysis and modal analysis. In chapter 4 inextensible circular arches are analyzed by the method of decomposition into forced and free vibration. Chapter 5 addresses the question of solution accuracy: the method of decomposition into forced and free vibration is compared with modal analysis, and the effects of tangential inertia forces are investigated.

Chapters 6 and 7 are concerned with the analysis of frames composed of straight and curved elements by two methods: the method of decomposition into forced and free vibration and the modal method. Chapter 8 generalizes the method of decomposition into forced and free vibration. The forcing function is represented as a piecewise linear function. Chapter 9 deals with the vibration of frames subject to prescribed motions. Chapter 10 deals with the vibration of space frames by matrix method. Chapter 11 presents some numerical and graphical results.

S. Holzer
Department of Civil Engineering
College of Engineering
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia 24061

VIBROMOTORS

R. Bansevičius and K. Ragulskis
Izd. "Mokslas," Vilnius, Lithuanian SSR
1981, 193 pp (in Russian)

Vibromotors are a new type of mechanical energy input device that are used in such high precision

instruments as robots and manipulators. Vibromotor operation is based on the conversion of high frequency mechanical vibrations (above 20 KHz) to a continuous or step motion. The idea of vibromotors emerged from low frequency vibrotransportation. The application of high frequency vibrations with low amplitudes (10^{-4} to 10^{-7}m) has introduced new physical features of operation and opened new fields of application in high precision technology. Vibromotors can solve all types of displacement operations with well controlled velocity. In comparison with conventional electric motors the application of vibromotors has several advantages; these include high sensitivity to displacement, low time constant in transient processes, wide temperature range of operation, independence of electromagnetic or radiation field noise, and possibility of miniaturization.

The monograph provides details of technical design and analysis of a variety of vibromotors and describes the application of vibromotors. Chapter 1 describes operational principles and provides a classification of vibromotors. The classification criteria are as follows:

- according to physical principle of operation: piezoelectric, piezomagnetic, electrodynamic, electromagnetic, pneumatic
- according to type of nonlinearity: oblique impact vibromotors, frictional vibromotors, traveling wave type vibromotors, vibromotors with nonsymmetric vibrations, vibromotors with controlled joints, vibromotors with external couple
- according to type of motion: rotational, linear, complex, with continuous or noncontinuous mechanical contact, or with air cushion
- according to the method of the speed control: with amplitude, frequency, or phase modulation; with parametric modification of nonlinearity
- according to possibility of variations of the speed direction: reversible or nonreversible
- according to the synchronism of motion: synchronous or nonsynchronous with the input
- according to the number of degrees of freedom and the kind of feedback
- according to the character of dynamic processes: vibromotors based on asymmetric vibrational cycles or vibromotors based on the use of controllable liquid contact between the vibrating member and the driven body by means of electro- or magneto-viscous liquids or solids having viscosity sensitive to variations of an ultrasonic field

A survey of research work on vibromotors, mostly published in the Soviet Union, is given. There are 134 references.

Chapter 2 discusses specific features of the technical design of vibration converters for vibromotors. Piezoelectric converters generating longitudinal or torsional vibrations and traveling wave-type converters are described.

Chapter 3 concentrates on the theory of vibromotors. The design calculations are divided in two steps: for the converter providing a required type of motion and for the entire nonlinear system -- converter plus rotor -- that guarantees the necessary force and velocity characteristics of the vibromotor. In particular, oblique impact vibromotors and torsional wave vibromotors are analyzed. The problem of synchronization of several parallel vibromotors is discussed.

Chapter 4 presents results of experimental testing of vibromotors operating in steady-state and transient regimes. Chapter 5 describes vibromotors having several degrees of freedom -- vibromotors with controlled kinematical pairs and controlled liquid joints -- applied in microrobots and micromanipulators. Chapter 6 discusses the fields of application of vibromotors and presents some practical examples.

The conclusion of the monograph indicates some trends for future development of vibromotors: increase of speed ranges and improvement of operational quality by the application of such new materials as elastic piezo-active alloys and sandwich structures of ferromagnetic or magneto-striction layers with piezo-ceramics controlled by both magnetic and electric fields. The monograph is intended for design and research engineers interested in high precision technology.

A. Muszynska
Mechanical Engineering Services
Bently Nevada Corporation
P.O. Box 157
Minden, Nevada 89423

SPECTRUM

Comment on "Optimal Vibration Reduction Over a Frequency Range"
(W.D. Pilkey, L. Kitis, and B.P. Wang, Shock Vib. Dig., 14 (11), pp 19-27, Nov 1982)

There are several additional references which should be of interest to readers of the interesting review article by Pilkey, Kitis, and Wang [A], partly because they preceded, and are referenced in, some of the references in [A]. Also, the information presented supplements that of the article.

Dana Young [B] presented a solution for a damped dynamic absorber attached to an undamped clamped-free beam. He uses the beam mass in the mass ratio μ, and then gives an approximate solution using one beam mode with $\mu' = \mu\phi^2(h)$. So he already is clearly using the modal mass as a reference. He showed that the approximate solution worked well near the first beam resonance, but not as well near the second resonance. He also found numerically the tuning frequency of the absorber and the location and heights of the fixed points.

Neubert [C] presents an exact solution for point and transfer mobilities where the primary system is a free-free bar having solid damping. The practical application may be related to the stretching or accordian modes of a submarine hull or of power plant piping. The idea to use solid damping for the bar came from Snowdon's paper [D]. Some of the results presented in [C] are:

1. Single absorbers are applied at various positions along the bar. For an absorber at the driven end, optimum tuning and damping are presented for various mass ratios for absorbers tuned to attenuate the first, second, and third bar resonances.

2. It is demonstrated that a tuned system becomes detuned when the damping of the primary system is changed.

3. Two absorbers are applied simultaneously to the bar, one at the driven end and one at the center. Each absorber is assigned almost the same values of optimum tuning and damping that were determined when the absorbers were attached individually (which can be done because the central absorber is near a node for the first mode). Optimum suppression of the first and second bar resonances results from this procedure.

4. The difference between displacement and velocity tuning is discussed for Den Hartog's [E] system. For displacement tuning Den Hartog gives

$$f = 1/1 + \mu \tag{1}$$

   For velocity tuning [C] gives

$$f^2 = (2 + \mu) \,/\, [2(1 + \mu)^2] \tag{2}$$

5. Modal effective mass is mentioned and the paper states that (strictly) modal mass cannot be used because "the slope (of the mobility curve) is different from what it would be if only a single mode were excited." To support this, the tuning data is now presented using the mass ratio as $\mu\phi^2(0)$ where the modal effective mass is one half the bar mass, as stated in the paper.

TABLE

		Bar, Optimum Tuning		
$\mu\phi^2(0)$	Damped System Equ. (2)	First Res	Second Res	Third Res
1/20	0.964	.965	.968	.973
1/15	.953	.949	.960	.967
1/10	.932	.931	.942	.962
1/5	.874	.875	.918	.949
1/2	.745	.780	.883	.940

6. It is demonstrated that simply adding the absorber mass, without the spring and dashpot, is more effective than the tuned absorber in reducing vibration at frequencies greater than the absorber's natural frequency.

Warburton [F] plotted the data from [C] and used it in support of the idea that the modal mass is a good reference mass, especially for small absorber masses. He plots optimum tuning ratio for one degree of freedom system, bar, cantilever beam, and shell to demonstrate the applicability of the assumed mode approach.

REFERENCES

[A] Pilkey, W.D., Kitis, L., and Wang, B.P., "Optimal Vibration Reduction Over a Frequency Range," Shock Vib. Dig., 14 (11), pp 19-27 (1982).

[B] Young, Dana, "Theory of Dynamic Vibration Absorbers for Beams," Proc. of First U.S. Congress of Applied Mechanics, ASME, New York, pp 91-96 (1952).

[C] Neubert, V.H., "Dynamic Absorbers Applied to a Bar that has Solid Damping," JASA, 36 (4), pp 673-680 (1964).

[D] Snowdon, J.C., "Representation of the Mechanical Damping Possessed by Rubberlike Materials and Structures," JASA, 35, p 821 (1963).

[E] Ormondroyd, J. and Den Hartog, J.P., "Theory of the Dynamic Vibration Absorber," Trans. ASME, 50, (1928).

[F] Warburton, G.B., "Reduction of Harmonic Response of Cylindrical Shells," J. Engrg. Industry, Trans. ASME, 91, pp 1371-1377 (1975).

Vernon H. Neubert, Professor
Department of Engineering Science
and Mechanics
The Pennsylvania State University
Hammond Building
University Park, Pennsylvania 16802

PREVIEWS OF MEETINGS

INTERNATIONAL SYMPOSIUM ON STRUCTURAL CRASHWORTHINESS
September 14-16, 1983
The University of Liverpool, England

It is the purpose of this Symposium to bring together people from various branches of the structural crashworthiness field to exchange views and information. The structural crashworthiness of aircraft (including helicopters), cars, buses, trains, ships and offshore platforms will be discussed as well as recent related studies into the behaviour of structural members.

The following papers will be presented:

- ***Laterally Compressed Metal Tubes as Impact Energy Absorbers*** -- S.R. Reid, Aberdeen University, Scotland
- ***The Static Approach to Plastic Collapse and Energy Dissipation in Some Thin-Walled Steel Structures*** -- N.W. Murray, Monash University, Australia
- ***Crushing Behaviour of Plate Intersections*** -- T. Wierzbicki, Massachusetts Institute of Technology, U.S.A.
- ***Energy Absorption by Structural Collapse*** -- P.H. Thornton, H.F. Mahmood and C.L. Magee, Ford Motor Company, U.S.A.
- ***Axial Crushing of Fibre Reinforced Composite Tubes*** -- D. Hull, University of Liverpool, England
- ***Impact Scalability of Plated Steel Structures*** -- E. Booth, D. Collier and J. Miles, Ove Arup and Partners, England
- ***Static and Dynamic Finite Element Analysis of Structural Crashworthiness in the Automotive and Aerospace Industries*** -- E. Haug, F. Arnaudeau, J. Dubois and A. DeRouvray, Engineering System International, France, and J. F. Chedmail, Engineering System International, West Germany
- ***Study of the Crash Behaviour of Aircraft Fuselage Structures*** -- R.C. Tennyson and J.S. Hansen, University of Toronto, Institute for Aerospace Studies, Canada
- ***Aircraft Crash Dynamics: Modelling, Verification and Application*** -- G. Wittlin, Lockheed-California, U.S.A.
- ***Application of the Nonlinear Finite Element Computer Program "DYCAST" to Aircraft Crash Analysis*** -- R.J. Hayduk, NASA Langley Research Center; R. Winter and A. Pifko, Grumman Aerospace; and E.L. Fasanella, Kentron International, U.S.A.
- ***Structural Aspects of Ship Collisions*** -- Norman Jones, University of Liverpool, England
- ***Collision Resistance of Marine Structures*** -- E. Pettersen, Trosvik Engineering and S. Valsgard, Det Norske Veritas, Norway
- ***Analysis of Frame-Type Safety Structures in Road Vehicles*** -- D. Kecman, Belgrade University, Yugoslavia
- ***Rail Vehicle Structural Crashworthiness*** -- Pin Tong, Department of Transportation, U.S.A.
- ***Structural Damage in Airship and Rolling Stock Collision*** -- W. Johnson, Cambridge University, England

Additional papers on various aspects of structural crashworthiness are currently being reviewed and will be presented at the Symposium. All papers will be printed and available for the Symposium.

The co-chairmen of the Symposium are Professor Norman Jones (Liverpool University) and Professor T. Wierzbicki (MIT).

For further information contact: Professor Norman Jones, Department of Mechanical Engineering, The University of Liverpool, P.O. Box 147, LIVERPOOL L69 3BX, England.

SHORT COURSES

MAY

COMPUTER SIMULATION OF HIGH VELOCITY IMPACT

Dates: May 10-13, 1983
Place: Baltimore, Maryland
Objective: This is an intensive short course dealing with material behavior under short duration loading, numerical methods for impact and penetration problems, a survey of two- and three-dimensional computer codes for impact and penetration studies as well as graphics packages for computational mesh generation and data analysis. Numerous applications involving impact, penetration and material failure under intense, short-duration loading will be presented to illustrate considerations essential for simulation of physical phenomena.

Contact: Dr. J.A. Zukas, Course Coordinator, Computational Mechanics Associates, P.O. Box 11314, Baltimore, MD 21239 - (301) 435-1411.

MULTICRITERION DECISION MAKING: COMPUTER METHODS AND ENGINEERING APPLICATIONS

Dates: May 17-25, 1983
Place: Tucson, Arizona
Objective: This course will demonstrate how to account for the multicriterion nature of decision and management problems in industrial, systems, mining, environmental, and civil engineering. A precise definition of system decision problems will be given and selected techniques presented and illustrated by examples. Real-world case studies and areas of potential applications will be discussed. Workshops will be held using own decision problems and demonstrating computer programs to perform analyses.

Contact: Special Professional Education, College of Engineering, Harvill Bldg., Room 237, University of Arizona, Tucson, AZ 85721 - (602) 626-3054.

ROTOR DYNAMICS

Dates: May 23-27, 1983
Place: Syria, Virginia
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

JUNE

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: June 6-10, 1983
Place: Santa Barbara, California
Dates: August 22-26, 1983
Place: Santa Barbara, California
Dates: October 24-28, 1983
Place: Boulder, Colorado
Dates: November 14-18, 1983
Place: Cincinnati, Ohio
Dates: December 5-9, 1983
Place: Santa Barbara, California

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (805) 682-7171.

MECHANICS OF HEAVY-DUTY TRUCKS AND TRUCK COMBINATIONS

Dates: June 13-17, 1983
Place: Ann Arbor, Michigan
Objective: This course describes the physics of heavy-truck components in terms of how these components determine the braking, steering, and riding performance of the total vehicle. Covers analytical methods, parameter measurement procedures, and test procedures, useful for performance analysis, prediction and design.

Contact: Continuing Engineering Education, 300 Chrysler Center, North Campus, The University of Michigan, Ann Arbor, MI 48109 - (313) 764-8490.

MACHINERY VIBRATION ANALYSIS

Dates: June 14-17, 1983
Place: Nashville, Tennessee
Dates: August 16-19, 1983
Place: New Orleans, Louisiana
Dates: November 15-18, 1983
Place: Chicago, Illinois
Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow-speed paper rolls.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

VIBRATION DAMPING

Dates: June 19-22, 1983
Place: Dayton, Ohio
Objective: The utilization of the vibration damping properties of viscoelastic materials to reduce structural vibration and noise has become well developed and successfully demonstrated in recent years. The course is intended to give the participant an understanding of the principles of vibration damping necessary for the successful application of this technology. Topics included are: damping fundamentals, damping behavior of materials, response measurements of damped systems, layered damping treatments, tuned dampers, finite element techniques, case histories, and problem solving sessions.

Contact: Michael L. Drake, Kettering Laboratory 104, 300 College Park Avenue, Dayton OH 45469 - (513) 229-2644.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of publications abstracted are not available from SVIC or the Vibration Institute, except those generated by either organization. Government Reports (AD-, PB-, or N-numbers) can be obtained from NTIS, Springfield, Virginia 22151; Dissertations (DA-) from University Microfilms, 313 N. Fir St., Ann Arbor, Michigan 48106; U.S. Patents from the Commissioner of Patents, Washington, DC 20231; Chinese publications (CSTA-) in Chinese or English translation from International Information Service Ltd., P.O. Box 24683, ABD Post Office, Hong Kong. In all cases the appropriate code number should be cited. All other inquiries should be directed to libraries. The address of only the first author is listed in the citation. The list of periodicals scanned is published in issues 1, 6, and 12.

ABSTRACT CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 710, 782)

83-663

Investigation of a Rotor System Incorporating a Constant Lift Tip

M.A. McVeigh, H. Rosenstein, K. Bartie, and F.J. McHugh

Boeing Vertol Co., Philadelphia, PA, Rept. No. NASA-CR-166261, 326 pp (Oct 1981)

N82-29271

Key Words: Rotors, Wind tunnel test data

A wind tunnel test of a 16.8 ft. model of a rotor having passively controlled pivotable tips is described. Performance and vibratory hub load data are presented which compare the performance of the rotor with the tips free and fixed. A brief analysis of the experimental findings is included.

83-664

The Calculation and Verification of Torsional Natural Frequencies for Turbomachinery Equipment Strings

R.E. Mondy and J. Mirro

Ingersoll-Rand, Phillipsburg, NJ, Turbomachinery Symposium, Proc. of the 11th, Texas A&M Univ., College Station, TX, Dec 14-16, 1982, pp 151-156, 11 figs, 4 tables

Key Words: Turbomachinery, Shafts, Torsional vibration, Natural frequencies, Mode shapes

The analytical techniques used to design turbomachinery equipment strings from a torsional dynamics standpoint are discussed. Consideration is also given to both torsional natural frequency placement and potential excitation sources. Three cases are presented wherein the torsional natural frequencies and mode shapes are calculated via Holzer Transfer Matrix computer code and the frequencies then verified by measurement on the actual hardware. The accuracy of both analytical and measuring techniques is discussed from the aspect of the minimum acceptable interference margins for acceptable equipment operation.

83-665

A Further Study on the Method of Stress Calculation for Torsional Vibration

Yun-xiu Xu, Xuan-xuan He, and Zhuo-chao Huang

Ship Engrg., (1), pp 35-40 (1982)

CSTA No. 623.8-82.07

Key Words: Shafts, Diesel engines, Ships, Torsional vibration

Based on a large amount of measurements and data from literature the authors present a method for a more accurate calculation of torsional shaft vibration of most low and medium speed diesel engines.

83-666

Recount of Torsional Characteristics of Shaft System of M/V "East Wind" - Space Pattern Analysis - Part 1

Bo Zhong Li, et al

Ship Engrg., (4), pp 26-34 (1982)

CTSA No. 623.8-82.39

Key Words: Shafts, Torsional response, Marine engines

The test results from four Geiger-Torsiographs connected in parallel to an amidship installation shaft system are used to determine the dynamic magnifiers in relation to the equilibrium amplitudes obtained from the natural frequency calculations. Choices of the damping coefficients of engine shaft and propeller are thence taken as the data input for the calculation of the space patterns of the Torsional Vibration System. The patterns thus obtained agree reasonably well as anticipated especially in the resonant zones with the measurements where the critical harmonic disturbances are dominating. Total effect of harmonic orders up to 12th altogether are also discussed.

83-667

Application of Recent Rotor Dynamics Developments to Mechanical Drive Turbines

W.J. Caruso, B.E. Gans, and W.G. Catlow

General Electric Co., Fitchburg, MS, Turbomachinery Symposium, Proc. of the 11th, Texas A&M Univ., College Station, TX, Dec 14-16, 1982, pp 1-17, 33 figs, 4 tables, 14 refs

Key Words: Steam turbines, Rotors, Bearings, Vibration analysis

Recent developments in rotor dynamics technology providing significant improvements in the correlation between theoretical analyses and actual rotor vibration response for mechanical drive steam turbines, are described. These developments involve analytical and experimental studies of tilting pad bearings, bearing supports, and steam force reactions. Examples of typical steam turbine designs of different sizes and speeds are analyzed, using the new concepts.

83-668

Rotor Dynamics Analysis and Bearing Optimization Study of a 3800 HP Steam Turbine

D.J. Salamone

Centritech Corp., Houston, TX, Turbomachinery Symposium, Proc. of the 11th, Texas A&M Univ., College Station, TX, Dec 14-16, 1982, pp 19-27, 22 figs, 6 tables, 5 refs

Key Words: Rotors, Dynamic structural analysis, Bearings, Steam turbines

This paper presents the highlights of a complete rotor dynamics analysis and bearing optimization study that was performed on a 3800 HP multistage steam turbine. The analysis shows that the turbine operates close to the second critical speed and that the rotor is stable under normal load conditions. However, the rotor becomes unstable when the lemon-bore bearings are unloaded.

83-669

Bearing Strength of Joints in Angular Extrusion Presses under Static and Dynamic Loads (Tragfähigkeit von Querpressverbänden bei statischer und dynamischer Belastung)

W. Beitz and G. Galle

Institut f. Maschinenkonstruktion/Konstruktionstechnik, Technische Universität Berlin, Germany, Konstruktion, 34 (11), pp 429-435 (1982) 4 figs, 6 tables, 13 refs

(In German)

Key Words: Shafts, Joints (junctions), Fatigue life, Torsional excitation

After a short review of the fundamentals of design and the state-of-the-art of angular extrusion press joints, the authors describe an extensive testing program. The friction contact and fatigue life of numerous designs under static and dynamic, torsional and frictional loads are investigated.

83-670

Finite Element-Integral Simulation of Static and Flight Fan Noise Radiation from the JT15D Turbofan Engine

K.J. Baumeister and S.J. Horowitz

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. E-1332, NASA-TM-82936, 16 pp (1982) (Presented at the Winter Ann. Mtg. of the ASME, Phoenix, AZ, Nov 14-19, 1982)

N82-31068

Key Words: Fans, Noise generation, Finite element technique, Computer programs

An iterative finite element integral technique is used to predict the sound field radiated from the JT15D turbofan inlet.

83-671

Discrete Frequency Noise and Its Reduction in Small Axial-Flow Fans

J.M. Fitzgerald

Applied Res. Lab., Pennsylvania State Univ., State College, PA, Rept. No. ARL/PSU/TM-82-76, 147 pp (Mar 2, 1982)

AD-A118 439

Key Words: Fans, Electronic instrumentation, Noise generation, Noise reduction

The discrete frequency noise radiated from representative types of axial-flow fans used in electronic equipment is studied in detail. Narrowband analysis of the discrete frequency noise radiated by these types of fans has been conducted in a free-field environment. The far-field sound pressure level, radiated directivity, and total radiated power of the discrete frequency noise is presented.

83-672

Assessment of Inflow Control Structure Effectiveness and Design System Development

A.A. Peracchio

Pratt & Whitney Aircraft Group, East Hartford, CT, J. Aircraft, 19 (12), pp 1045-1051 (Dec 1982) 9 figs, 2 tables, 5 refs

Key Words: Turbofan engines, Fans, Aircraft engine, Engine noise

Use of inflow control structures during static testing of fans is shown to minimize inflow distortions, thereby simulating the fan's inflight flowfield and noise generating mechanisms. Results of acoustic testing of a Pratt and Whitney Aircraft JT9D engine with and without an inflow control structure are presented and compared, after projection to flight, with measured flight levels from a JT9D equipped Boeing 747 aircraft. The use of an inflow control structure is shown to significantly reduce the blade passage frequency tone and to improve agreement between static data projected to flight and the flight data. The inflow control structure had a negligible effect on the tone at twice blade passage frequency. A design procedure is also presented that prescribes the inflow control structure shape, size, and detailed construction.

83-673

Shop Full-Load Testing of Centrifugal Compressors

A. Maretti, M. Giovannini, and P. Nava

Functional Test Dept., Nuovo Pignone, Italy, Turbomachinery Symposium, Proc. of the 11th, Texas A&M Univ., College Station, TX, Dec 14-16, 1982, pp 113-120, 14 figs, 1 table, 11 refs

Key Words. Compressors, Centrifugal compressors, Dynamic tests

The main features of full-load tests for verifying the rotordynamic stability of compressors at high pressure in the field of natural gas machinery are described. The tests include both single compressors and the whole system.

RECIPROCATING MACHINES

(See No. 742)

METAL WORKING AND FORMING

83-674

A Mathematical Model of Machining Chatter

D.-J.W. Wu

Ph.D. Thesis, Purdue Univ., 161 pp (1982)
DA8225788

Key Words: Machinery noise, Chatter, Cutting

A mathematical model of machining chatter has been developed through an analytical approach in order to predict dynamic cutting force from steady-state cutting tests. The model is derived from a pseudo-static geometric configuration of the cutting process, and by taking into account the fact that the mean friction coefficient fluctuates dynamically responding to variation of the relative speed on the chip-tool interface. The force functions through this derivation can be used to explain all three basic mechanics associated with chatter vibration, namely, velocity dependent, regenerative, and mode coupling mechanisms. The model is successful in predicting the forms of stability boundary over a wide range of cutting speed It reveals that the cutting force applying on the tool rake face controls the high speed stability.

83-675

The Computation and Analysis of Torsional Vibration in the Driving System of Machine Tools

Zhongyi Chen and Chengwen Cai

J. Chekiang Univ., (4), pp 91-102 (1981)
CSTA No. 621.8-81.24

Key Words: Machine tools, Torsional vibration

Torsional vibrations in the driving system is one of the main research objects of machine tools. This paper presents the following method to compute the eigenvalues and eigenvectors of torsional vibrations. After symmetrizing the unsymmetrical dynamic matrix, the eigenvalues and eigenvectors of torsional vibrations in the driving system and their branches can be computed by the Jacobi's method This method is used to treat the torsional vibration in the driving system of Y38 gear hobbing machine with success. The computing results are agreeable with practical measurements.

ELECTROMECHANICAL SYSTEMS

83-676

Random Vibration of Electrodynamic Vibration Machine at White Noise Excitation

De-Chang Hsi

Chinese J. of Mech. Engrg., 18 (2), pp 35-46 (1982)
CSTA No. 621.8-82.67

Key Words: Electrodynamic shakers, Random vibration, Power spectral density, Mean square response, Displacement analysis, Acceleration analysis, Velocity

In this paper, the formulas of power spectral density and of mean square value of displacement, velocity, acceleration

and electric current of moving coil frame of electrodynamic vibration machine are derived when electric current or voltage is the ideal white noise power spectral density of the input. This method of increasing mean square value of displacement, velocity and acceleration and of decreasing mean square value of electric current are proposed. The curve figures of power spectral density and of mean square value of displacement, velocity, acceleration and electric current are given through calculation. The formulas and the curve figures in this paper can be used to design random vibration machine.

The report presents briefly the current state of technology in five areas of interest to engineers responsible for highway bridge repair and maintenance, namely: concrete bridge decks, accidental damage, fatigue damage in steel members, scour at bridge sites, and retrofit procedures to minimize seismic damage. Also included is a brief discussion of several recently developed replacement systems that can be used for bridges on rural roads and descriptions of the procedures used in the replacement of the bridge deck on the George Washington Bridge and the deck replacement system used on bridges on the New York Thruway.

STRUCTURAL SYSTEMS

BRIDGES

83-677

Fatigue Life of Critical Members in a Railway Truss Bridge

V.K. Garg, Kuang-Han Chu, and A. Wiriyachai

Dynamics Res. Div., Assn. of American Railroads, Chicago, IL, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (6), pp 779-795 (Nov/Dec 1982) 15 figs, 7 tables, 41 refs

Key Words: Bridges, Structural members, Railroad trains, Freight cars, Fatigue life

The fatigue life of critical members, such as hangers, floorbeams and stringers in a single track, open deck railroad truss bridge, was investigated for various unit freight trains, operating at different speeds. A partial bridge model was used, along with a three-car train, to determine the stress cycles.

83-678

Rehabilitation and Replacement of Bridges on Secondary Highways and Local Roads

Dept. of Civil Engrg., Virginia Univ., Charlottesville, VA, Rept. No. TRB/NCHRP/REP-243, ISBN-0-309-03408-6, 56 pp (Dec 1981)
PB82-260076

Key Words: Bridges, Roads (pavements), Fatigue life, Seismic response

83-679

Calculation of the Internal Forces in Long Span Half-Through R.C. Arch Bridge Subjected to Lateral Wind Load

C. Hongde

J. of China Railway Society, 4 (1), pp 65-75 (1982)
CSTA No. 625.1-82.07

Key Words: Bridges, Reinforced concrete, Wind-induced excitation

In this paper, the internal forces with regard to the three axes of the different calculating sections of arch ribs in long span half-through R.C. arch bridge subjected to lateral wind load are calculated by treating it as a space structure.

83-680

Suspension Bridge Vibration: Continuum Formulation

A.M. Abdel-Ghaffar

Princeton Univ., Princeton, NJ, ASCE J. Engrg. Mech., 108 (EM6), pp 1215-1232 (Dec 1982) 9 figs, 2 tables, 8 refs

Key Words: Bridges, Suspension bridges, Seismic excitation, Vertical vibration, Lateral vibration, Torsional vibration

The methodology of the free vibration analysis of suspension bridges with horizontal decks is refined and extended, utilizing a continuum approach to include both the coupled vertical-torsional vibration and the effect of crosssectional distortion. The general, nonlinear equations of motion governing the lateral vibration of suspension bridges are presented and the linearized forms are obtained; a numerical example and a comparison among the analytical, numerical and full-scale test results are also presented.

83-681
Suspension Bridge Response to Moving Loads
T. Hayashikawa and N. Watanabe
Dept. of Civil Engrg., Hokkaido Univ., Nishi 8 Kita 13 Kita-ku, Sapporo, 060, Japan, ASCE J. Engrg. Mech., 108 (EM6), pp 1051-1066 (Dec 1982) 8 figs, 3 tables, 14 refs

Key Words: Bridges, Suspension bridges, Moving loads, Modal analysis

An analytical method for determining natural frequencies and mode shapes of multispan bridges is developed by using a solution for the fourth order linearized differential equations. This method takes into account the support conditions of stiffening girders and the effect of flexural stiffness of towers and can be calculated to higher eigenvalues accurately. The dynamic response of multispan suspension bridges traversed by moving loads with constant velocity is studied. The analysis is conducted by the method of modal analysis. A numerical example is presented to demonstrate the applicability of the analysis and to investigate the dynamic characteristics of suspension bridges.

BUILDINGS
(Also see Nos. 722, 723)

83-682
Assessment of Lateral and Torsional Stiffness Characteristics of Medium Rise Concrete Buildings
M. Mirtaheri and P.R. Sparks
College of Engrg., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Rept. No. VPI-E-82-24, 197 pp (Sept 1982)
PB83-101238

Key Words: Buildings, Concretes, Natural frequencies, Mode shapes

Design assumptions for five concrete buildings, each representing a different structural system, were evaluated by comparing theoretical results with experimental data on dynamic characteristics. Initial estimates of the natural frequencies and mode shapes were made by using the TABS-77 program. Model improvements were made by incorporating the effects of 'non-structural' partitions and cladding and by considering the efficiency of elevator cores. Improvements were made until theory and experimental results matched for both natural frequencies and mode shapes. Implications of incorrect modeling were investigated for both static and dynamic lateral loadings.

83-683
Fluctuating Wind Loads on Buildings
A. Kareem
Univ. of Houston, Houston, TX, ASCE J. Engrg. Mech., 108 (EM6), pp 1086-1102 (Dec 1982) 9 figs, 2 tables, 17 refs

Key Words: Buildings, Wind forces, Wind-induced excitation

A method for evaluating the fluctuating wind forces and their distribution on buildings has been developed and applied to the understanding and quantification of crosswind loads on a square cross-section building. Wind loads are determined by integrating simultaneously monitored pressure fluctuations on a building model surface in a boundary layer wind tunnel. An example is presented to illustrate that a suitable combination of a limited number of pressure transducers can be used to monitor pressure fluctuations for the estimation of multi-level wind loads on building models. This methodology also provides information on the local spatio-temporal variation of pressure fluctuations which can provide useful input to the cladding design. Power spectral density and chordwise variation of co-spectra between locations at one level on the model surface are presented. The cross power spectral density matrices of the crosswind forcing function are developed for urban and suburban flow conditions.

83-684
Steel Structures Subjected to Dynamic Loads in Connection with Progressive Collapse. Dynamic Buckling
P. Christiansson
Swedish Council for Bldg. Res., Stockholm, Sweden, Rept. No. ISBN-91-540-3681-X, 120 pp (1981)
PB82-262122

Key Words: Buildings, Steel, Dynamic buckling

When a building is subjected to local damage there is a risk that the damage will develop into a progressive collapse. One way of reducing this risk is to provide for an alternative load-carrying system. It is however possible that the structure will not sustain the dynamic effects during the transition stage before the alternative bearing system is developed. This report contains a study of the dynamic transition stage, with special reference to dynamic column buckling.

83-685
Simplified Method of Analysing Single-Story Mill Buildings under Longitudinal Seismic Action
Cuiru Yang, et al

J. of Bldg. Structure, 3 (2), pp 46-55 (1982)
CSTA No. 624-82.12

Key Words: Industrial facilities, Earthquake response, Seismic excitation

For single-story mill buildings, the current design practices in the analysis of longitudinal earthquake responses either completely ignore the stiffness of the roofing system or treat it as an absolutely rigid diaphragm. In this paper, according to the experimental data and conclusions drawn from earthquake damage surveys, a spatial structural analyzing model in consideration of the deformability of the roofings and the effective stiffness of the longitudinal walls is established. With the aid of computer, a number of different mill-type buildings have been analyzed and the results studied. Based on these data of spatial structural analysis, a simplified method of analyzing single-story mill buildings under longitudinal seismic action is proposed and the calculation can be done with hand computation.

FOUNDATIONS
(Also see No. 761)

83-686
Efficient Elastic Design of Small Foundations
G.J. O'Hara and P.F. Cunniff
Naval Res. Lab., Washington, DC, Rept. No. NRL-MR-4886, 13 pp (Sept 13, 1982)
AD-A119 343

Key Words: Foundations, Shock response spectra

An elastic design analysis method is presented for small foundations which utilize an energy criteria. It provides a direct approach for calculating allowable loads and for estimating the design efficiency of the resulting structure. The method has the advantage of circumventing the standard method for single degree of freedom systems in first calculating the fixed base frequency, utilizing shock design spectra, and equivalent static load analyses. A sample problem is presented that shows how to establish maximum allowable equipment weight for a shock. The results are worked up in some detail to show the ease of application of this method.

83-687
Torsional Dynamic Response of Solid Systems
R. Henke, E.B. Wylie, and F.E. Richard, Jr.
Exxon Production Res. Co., Houston, TX 77001, ASCE J. Engrg. Mech., 108 (EM6), pp 1067-1085 (Dec 1982) 22 figs, 6 refs

Key Words: Torsional response, Interaction: soil-foundation

A practical numerical method which solves the multidimensional axisymmetric torsional wave equation for linear and nonlinear inelastic solids was developed in 1980. The application of this procedure is the prediction of the dynamic response of soil-foundation systems subjected to torsional loads having a broad range of intensities. Here the method is further validated. Two solutions giving the steady state response of a linear half space to different loadings are found to agree with analytical solutions. A third study considers the transient response of a rigid disk on a nonlinear as well as linear half space. Slip is permitted at the interface between the disk and half space. Since analytical solutions were not found, examples are validated using an energy balance. In all studies physical and mathematical aspects of the solutions are discussed. It is concluded that to predict accurately the dynamic response of a soil-foundation system, nonlinear inelasticity must be taken into account if large shearing strains are developed and that the developed numerical method is practical and accurate.

UNDERGROUND STRUCTURES

83-688
The Response of Culverts to Earthquake Excitation
M. Beikae
Ph.D. Thesis, Univ. of California, Berkeley, 345 pp (1981)
DA8211852

Key Words: Earthquake damage

Since flexible metal culvert structures are being used with increasing frequency as highway and rail road bridges, the behavior of these systems under dynamic loads such as those produced by earthquakes was investigated.

83-689
Rigid Block Model for Transient Analysis of Rock Structures
H.-J. Yen
Ph.D. Thesis, Northwestern Univ., 130 pp (1982)
DA8226051

Key Words: Rocks, Transient analysis, Wave propagation

A numerical procedure has been developed for the transient analysis of caverns in jointed rock masses, wherein deformable finite elements are coupled with rigid block elements. The finite elements allow wave propagation through the rock mass and/or modeling of a liner and the rigid blocks incorporate an edge-to-edge sliding algorithm to permit realistic modeling of joint behavior. The validity of the procedure for coupling finite elements to rigid blocks is investigated with two numerical examples; response of a rigid mass on an elastic column, and response of a lined cavern in a sparsely jointed medium. The validity of the edge-to-edge sliding procedure is also investigated with two numerical examples.

HARBORS AND DAMS

83-690

Nonlinear Dissipative Finite Element Models for Harbor Resonance Problems

M.B.H. Ganaba

Ph.D. Thesis, Univ. of Southern California (1982)

Key Words: Harbors, Resonant response, Finite element technique

The major aim of the present study is to investigate theoretically and numerically, the response of harbors of arbitrary shape of nonuniform depth to incident long-period waves.

ROADS AND TRACKS

(Also see No. 678)

83-691

Dynamic Rail Overturning: Modelling and Application

M.A.M. Torkamani, M.H. Bhatti, and A.M. Zarembski

Univ. of Pittsburgh, Pittsburgh, PA, ASCE J. Engrg. Mech., 108 (EM6), pp 1330-1350 (Dec 1982) 16 figs, 14 refs

Key Words: Railroad tracks, Dynamic response

An analytical model for examining the dynamic equilibrium is utilized to determine the lateral deflection and rotation of the rail subjected to time dependent lateral and vertical forces, and constant axial force.

CONSTRUCTION EQUIPMENT

(See No. 830)

POWER PLANTS

(Also see No. 836)

83-692

Identification of Vibrational Effects in KNK II Fuel Elements

W. Vaeth, F. Mitzel, and S. Ansari

Inst. fuer Neutronenphysik und Reaktortechnik, Kernforschungszentrum Karlsruhe GmbH, Fed. Rep. Germany, Rept. No. KFK-3157, 18 pp (June 1981) DE82750094

Key Words: Nuclear fuel elements, Power spectral density

Several observations indicate vibrational effects in some fuel elements of the KNK-II core. This report describes how the coolant outlet temperature of each fuel element was used successfully as a means of the identification of these vibrations. As a result the cause of the sharp peaks in the power spectral density of the KNK-II reactivity noise was found.

83-693

Seismic Analysis of the Core of a PWR Reactor

A. Preumont

Societe Belge pour L'Industrie Nucleaire, Brussels, Belgium, Rept. No. BN-8102-03, 187 pp (1981) DE82701709

(In French)

Key Words: Nuclear power plants, Seismic response

The author develops successively: a method for the generation of accelerograms compatible with the response spectrum; a model for the analysis of lateral deformations of the core of a PWR reactor under seismic excitation; a simple dynamic model of the fuel assembly including a vibration model.

83-694

Evaluation of Aircraft Crash Hazards Analyses for Nuclear Power Plants

C.A. Kot, H.C. Lin, J.B. van Erp, T.V. Eichler, and A.H. Wiedermann

Argonne Natl. Lab., IL, Rept. No. ANL-CT-81-32, 128 pp (June 1982)

NUREG/CR-2859

Key Words: Nuclear power plants, Crash research (aircraft)

The state of knowledge concerning aircraft crash hazards to nuclear power plants is critically evaluated.

83-695

Analysis of Parameter Uncertainties in the Assessment of Seismic Risk for Nuclear Power Plants. Final Report, 1 June 1979 - 31 May 1980

S.M. Yucemen

International Atomic Energy Agency, Vienna, Austria, Rept. No. IAEA-R-2381-F, 96 pp (Apr 1981)

DE82701710

Key Words: Nuclear power plants, Seismic response

Probabilistic and statistical methods are used to develop a procedure by which the seismic risk at a specific site can be systematically analyzed.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 832, 860, 870)

83-696

Theoretical Analysis of Tractor Ride Vibration

Yuan-yu Ye

Trans. of Chinese Soc. of Agri. Mach., (1), pp 19-32 (1982)

CSTA No. 631.3-82.03

Key Words: Tractors, Suspension systems (vehicles), Seats

This paper gives a comprehensive introduction to various dynamic models of ride vibration used in the current research on tractors, and a general review of the static and dynamic load behavior of several seat suspension designs. A dynamic model of single-degree-of-freedom type is used and some illustrated examples are given.

83-697

Vertical Vibration of a Wheel Tractor During Movement with a Trunk

L. Starek

Dept. of Technical Mechanics of Faculty of Mech. Engrg., Slovak Technical Univ., 812 31 Bratislava, Czechoslovakia, Strojnicky Casopis, 33 (5), pp 563-573 (1982) 5 figs, 5 refs

Key Words: Tractors, Articulated vehicles, Vertical vibration, Power spectral density

A mathematical model of a five degree of freedom dynamic system for the analysis of vertical vibrations of wheel tractor under operating conditions is proposed. The model is verified by comparing the calculated power spectral densities with those obtained by experiment.

83-698

The Model Synthesis Technique in Dynamic Characteristic and Random Vibration Response Analysis for the Structure of Tractor-Trailer System

Zhao-chang Zheng, et al

Trans. of Chinese Soc. of Agri. Mach., (1), pp 33-45 (1982)

CSTA No. 631.3-82.04

Key Words: Articulated vehicles, Random vibration

In this paper, the methods of dynamic characteristics and random vibration response analysis for the structure of tractor-trailer system are presented. By using the modal synthesis technique, the order of dynamic matrices is decreased. The duration of computing time is greatly reduced. At the same time an identical computing mode for the studies of dynamic strength and comfortability of the seat of the vehicles is obtained.

SHIPS

(Also see No. 666)

83-699

Stochastic Theory of the Slamming Response of Marine Vehicles in Random Seas

A.E. Mansour and J. Lozow
Univ. of California, Berkeley, CA, J. Ship Res., 26 (4), pp 276-285 (Dec 1982) 6 figs, 1 table, 18 refs

Key Words: Ships, Slamming, Random waves, Wave forces

A stochastic theory is developed for the dynamic response of marine vehicles to slamming loads in random seas. Based on slamming observations and records, the slams are temporally represented as a train of Poisson impulses of random intensity occurring at random time intervals. Modal analysis is used to derive the impulse response and system functions of the marine vehicle. The probability density functions, spectral densities, autocorrelation functions, and other relevant statistics of both the input slams and the output vehicle response are developed and discussed. Special attention is given to the bending moment response. A numerical example is given in the last section in order to illustrate the application of the presented theory.

83-700

Shock-Excited Vibrations with Application to the Slamming Response of a Flexible Ship to a Regular Wave Packet

E. Suhir
Exxon International Co., Florham Park, NJ, J. Ship Res., 26 (4), pp 269-275 (Dec 1982) 3 figs, 14 refs

Key Words: Ships, Ship hulls, Slamming, Shock excitation, Vibration response, Periodic response, Transient response

Deterministic and probabilistic approaches to the problem of transient and steady-state linear oscillations of a one-degree-of-freedom system, subjected to repetitive shock loads, are developed. The case of the slamming response of a flexible ship hull to a regular wave packet is used to illustrate and to compare both techniques. It is concluded that the probabilistic approach is the more realistic when choosing guidelines for prediction and standardization of overall ship strength with consideration of slamming.

83-701

Effect of Parametric Excitation on Ship Rolling Motion in Random Waves

J.B. Roberts
School of Engrg. and Appl. Sciences, Univ. of Sussex, Brighton, UK, J. Ship Res., 26 (4), pp 246-253 (Dec 1982) 3 figs, 22 refs

Key Words: Ships, Parametric excitation, Random waves

An equation of motion for uncoupled ship rolling motion in irregular seas is considered in which parametric excitation, arising from the time dependence of the restoring moment, is included.

83-702

Stern Lines and Afterbody Vibrations of 7,000 M Lumber Carrier

Ming-hua Ying and Jun Liu
Ship Engineering, (1), pp 7-12 (1982)
CSTA No. 623.8-82.03

Key Words: Ships, Cargo ships

The authors, through an example of designing 7,000 M lumber carrier, give a clear analysis and quantitative description for relations between the afterbody vibrations and the section lines of stern.

83-703

An Approximate Computation for Natural Frequencies of Vertical and Horizontal Vibration of Ship Hulls

De-you Zhao
Ship Engineering, (1), pp 13-19 (1982)
CSTA No. 623.8-82.04

Key Words: Ship hulls, Natural frequencies, Statistical analysis

Based on the statistical analysis of the testings on-board 100 ships, the author presents the formulas approximately calculating the natural frequencies of vertical and horizontal vibration of ship hull.

AIRCRAFT

(Also see Nos. 716, 718, 727, 728, 812, 833, 859)

83-704

Direct Measurement of Transmission Loss of Aircraft Structures Using the Acoustic Intensity Approach

Y.S. Wang and M.J. Crocker

Ray W. Herrick Labs., Purdue Univ., West Lafayette, IN 47907, Noise Control Engrg., 19 (3), pp 80-85 (Nov/Dec 1982) 10 figs, 15 refs

Key Words: Aircraft noise, Noise transmission, Interior noise, Measurement technique, Microphone technique, Acoustic intensity method

Laboratory tests were conducted on a light aircraft fuselage to investigate its sound transmission paths. The two-microphone acoustic intensity method was utilized to measure the acoustic intensity transmitted to the interior when the fuselage was exposed to an external random incidence sound-field. It has been found that it is possible to estimate accurately the intensity transmitted through different sections of the fuselage with this new measuring technique. The studies show that the plexiglass window is the major transmission path in the high frequency range. The transmission losses through a single layer window and a double layer window were also predicted theoretically by using a statistical energy analysis model. The agreement between predictions and the measurements is very good.

83-705

Flight Test of the 747-JT9D for Airframe Noise

O. Kipersztok and G. Sengupta

Boeing Commercial Airplane Co., Seattle, WA, J. Aircraft, 19 (12), pp 1061-1069 (Dec 1982) 24 figs, 7 refs

Key Words: Aircraft noise, Noise generation

This paper describes the method used to isolate the individual airframe noise components and determine their relative contribution to the total noise radiated by a 747 aircraft with JT9D-7A engines at approach. The individual components are isolated using ensemble averaged flight test data. The spectral data are normalized on the basis of altitude, airspeed, temperature, and relative humidity. The noise radiated at approach is reconstructed from addition of individual components and compares very accurately in level, spectral shape, and directivity pattern to the actual flyover. A comparison is made between each individual airframe noise component, their logarithmic sum representing the synthesized total airframe component, and Fink's prediction method.

83-706

Prediction of Jet Exhaust Noise on Airframe Surfaces During Low-Speed Flight

L.M. Butzel

Boeing Commercial Aircraft Co., Seattle, WA, J. Aircraft, 19 (12), pp 1038-1044 (Dec 1982) 25 figs, 1 table, 14 refs

Key Words: Aircraft noise, Jet noise

The behavior of pressure fluctuations measured on the airframe of a prototype high-lift jet transport (YC-14) is presented. Efforts to characterize the data in terms of a modest number of parameters and the resulting prediction procedures are described. Comparisons with near field engine exhaust noise of a conventional jet transport (Boeing 747) are presented. The results suggest that at low speeds the same exhaust noise source is important for both aircraft types. The results also suggest a consistent frequency sensitivity, as well as level sensitivity to airplane velocity. The frequency result appears to be new data.

83-707

Airport Noise: Land-Use Compatibility by the Year 2000

R.J. Koenig and J. Tyler

Office of Noise Abatement and Control, Environmental Protection Agency, Washington, DC, Rept. No. EPA-550/9-82-344, 98 pp (Aug 1982)
PB82-259151

Key Words: Airports, Aircraft noise

This report reviews the progress which has been made in airport noise control and presents a forecast of changes in aviation noise exposure that will occur during the balance of this century. Results are given of an analysis which examines the benefits of noise abatement flight operations, flight procedures and of restrictions on population encroachment, on residential noise exposure. Cost of residential soundproofing and relocation, based upon indepth studies, are presented for four air carrier airports which represent four airport categories. While the main focus of the report is on noise exposure above Ldn 65 at air carrier airports, noise exposure around general aviation and joint-use civil/military airports is also discussed.

83-708

The Effect of Backlash and Trailing-Edge Strips on the Flutter Speed of a Two-Dimensional Model of a Tailplane with Tab

B. Emslie and A. Goldman

Structures Div., Aeronautical Res. Labs., Melbourne, Australia, Aeronaut. J., 86 (859), pp 337-340 (Nov 1982) 3 figs, 3 tables, 4 refs

Key Words: Aircraft, Flutter, Wind tunnel testing

The effect of backlash and trailing-edge strips on the flutter speed of a two-dimensional model of a tailplane with tab has been investigated in a series of wind tunnel tests. When backlash is present, a change in preload, which is achieved by varying the incidence of the tab, can dramatically alter the flutter speed. The addition of trailing-edge strips to the tab lowered the flutter speed.

83-709

A New Approach to Weapon Separation Aerodynamics

F.A. Tessitore, A. Cenko, R.C. Meyer, R.D. Dyer, and J.D. Waskiewicz

Grumman Aerospace Corporation, Bethpage, NY, J. Aircraft, 19 (12), pp 1070-1075 (Dec 1982) 19 figs, 8 refs

Key Words: Aircraft, Wing stores, Aerodynamic loads

An innovative approach has been developed for predicting the aerodynamic forces and moments acting on a store during separation from a parent aircraft. The method utilizes data obtained for one store in the flowfield to predict the forces and moments of another store in the same flowfield by identifying the local angle-of-attack distribution in proximity to the parent aircraft. Extensive comparisons between theory and test are shown for two different parent models, each with two different stores (four stores in all) at supersonic speeds, indicating the excellent correlation achieved. The potential for substantial wind tunnel cost savings is identified.

83-710

Rotor Aerodynamics in Ground Effect at Low Advance Ratios

H.C. Curtiss, Jr., W.F. Putman, and E.J. Hanker, Jr.

Dept. of Mech. and Aerospace Engrg., Princeton Univ., NJ, Rept. No. MAE-1571, 163 pp (July 27, 1982)

AD-A118 609

Key Words: Rotors, Helicopters, Aerodynamic loads

The results of an experimental study of the aerodynamic characteristics of a helicopter rotor operating in ground effect at low advance ratios are presented. Flow visualization studies were conducted along with measurement of the forces and moments acting on the rotor as a function of advance ratio, height above ground and collective pitch. Steady state experiments as well as non-steady experiments involving translational acceleration were conducted.

83-711

A Note on the General Scaling of Helicopter Blade-Vortex Interaction Noise

F.H. Schmitz, D.A. Boxwell, S. Lewy, and C. Dahan

American Helicopter Society, Inc., Washington, DC, 14 pp (May 1982) (Presented at the Annual Forum of the American Helicopter Society (38th), Anaheim, CA)

AD-A118 761

Key Words: Helicopter noise, Propeller blades, Noise generation, Scaling

A model-rotor acoustic experiment in a three meter open section anechoic wind tunnel (CEPRA-19) is described. The important scaling parameters are reviewed and some on-line acoustic data are presented for conditions known to produce blade-vortex interaction noise on a single rotor helicopter. Time averages of the model-scale acoustic pulses are compared with similar full-scale data taken in-flight under the same non-dimensionalized conditions.

MISSILES AND SPACECRAFT

83-712

Controllability of Inherently Damped Large Flexible Space Structures

A.S.S.R. Reddy and P.M. Bainum

Howard Univ., Washington, DC, Rept. No. NASA-CR-169127, 10 pp (1982)

N82-28345

Key Words: Spacecraft, Damped systems

Graph theoretic techniques are used to study controllability of linear systems which represent large flexible orbiting space systems with inherent damping. The controllability of the pair of matrices representing the system state and control influence matrices is assured when all states in the model are reachable in a digraph sense from at least one input and also when the term rank of a Boolean matrix whose nontrivial components are based on the state and

control influence matrices has a term rank of the order of the state vector. The damping matrix does not influence the required number of actuators but gives flexibility to the possibility locations of the actuators for which the system is controllable.

BIOLOGICAL SYSTEMS

HUMAN

83-713

The Response to Railway Noise in Residential Areas in Great Britain

J.M. Fields and J.G. Walker
Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 85 (2), pp 177-255 (Nov 22, 1982) 16 figs, 24 tables, 40 refs

Key Words: Traffic noise, Railroads, Noise measurement, Human response

The effects of railway noise on residents have been measured with a combined social survey (1453 respondents) and noise measurement survey (over 2000 noise measurements) at 403 locations in 75 study areas in Great Britain. In the analysis of the data methods have been used which take into account many typical noise survey problems including noise measurement errors, unique locality effects and the weakness of the noise annoyance relationship.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see No. 870)

83-714

Resonant Porous Material Absorbers

J.A. Moore and R.H. Lyon
Cambridge Collaborative, Inc., 225 Third St., P.O. Box 74, Cambridge, MA 02142, J. Acoust. Soc. Amer., 72 (6), pp 1989-1999 (Dec 1982) 16 figs, 4 refs

Key Words: Absorbers (materials), Acoustic absorption, Porous materials

A theory for the propagation of sound in a resistive porous material is formulated in terms of the bulk elastic properties of the structure of the porous material and the permeating fluid. Impedance relations are developed to describe the acoustic behavior of porous material layers of finite thickness. The acoustic behavior of resistive screens and impervious septa is also characterized. An analytical procedure is outlined for evaluating the sound absorption characteristics of different coating configurations consisting of arrangements of porous material layers, impervious septa, and resistive screens. A novel design configuration is described that achieves optimal sound absorption levels at low frequency in air. The coating is lightweight and also thin in comparison with an equivalent layer of uniform absorbing material. The dynamic behavior of the design is explained in physical terms.

83-715

Behavior of Magnetic Dynamic Absorber

J. Inoue and Y. Kurakake
Kyushu Univ., 6-10-1, Hakozaki, Higashiku, Fukuoka-City, Japan, Bull. JSME, 25 (209), pp 1781-1788 (Nov 1982) 6 figs, 1 table, 4 refs

Key Words: Dynamic absorbers, Magnetic properties

In this paper concerning a system with a damped magnetic dynamic absorber excited by an external periodic force, the regions and probabilities of occurrence of disturbances in initial conditions which realize steady solutions of the system were calculated and solved by Tondl's method.

83-716

Helicopter Vibration Suppression Using Simple Pendulum Absorbers on the Rotor Blade

G.A. Pierce and M.N.H. Hanouva
School of Aerospace Engrg., Georgia Inst. of Tech., Atlanta, GA, Rept. No. NASA-CR-169131, 140 pp (1982)
N82-28282

Key Words: Pendulums, Vibration absorption (equipment), Propeller blades, Blades, Helicopter vibration, Vibration control

A comprehensive analytical design procedure for the installation of simple pendulums on the blades of a helicopter rotor to suppress the root reactions is presented. A frequency response analysis is conducted of typical rotor blades excited by a harmonic variation of spanwise airload distributions as well as a concentrated load at the tip. The results presented included the effect of pendulum tuning on the minimization of the hub reactions.

83-717

Balloon-Skirt Airbags as Airdrop Shock Absorbers: Performance in Vertical Drops

W. Nykvist

Army Natick Res. and Dev. Labs., MA, Rept. No. NATICK/TR-82/026, 50 pp (Dec 1981)

AD-A118 228

Key Words: Air bags (soft landing), Shock absorbers, Air drop operations, Energy absorption

A set of 8 balloon-skirt airbags obtained from France were designed to dissipate impact energy of the 8 m/s vertical impact due to parachute airdrop, and provide a ground slide feature to dissipate horizontal velocity. A test platform was designed and fabricated. Forty-three vertical drops were carried out, with mass ranging from 970 to 2390 kg and impact velocity from 5.5 to 8 m/s. Platform position and acceleration, and selected airbag pressures were recorded vs time for each drop; high speed motion picture coverage was provided for many drops. Variation of platform acceleration with load mass and impact velocity was determined for two choke sizes.

83-718

Analysis of the Crush Environment for Lightweight Air-Transportable Accident-Resistant Containers

J.D. McClure and W.F. Hartman

Sandia National Labs., Livermore, CA, Rept. No. SAND-80-0783, TTC-0079, 27 pp (Dec 1981)

DE82013236

Key Words: Containers, Packaging, Compressive strength, Energy absorption, Radioactive materials, Air cargo, Air transportation

This report describes the longitudinal dynamic crush environment for a lightweight air-transportable accident-resistant container (LAARC, now called PAT-2) that can be used to transport small quantities of radioactive material. The analysis of the crush environment involves evaluation of the forces imposed upon the LAARC package during the crash of a large, heavily loaded, cargo aircraft. To perform the analysis, a cargo load column was defined which consisted of a longitudinal prism of cargo of cross-sectional area equal to the projected area of the radioactive-material package and length equal to the longitudinal extent of the cargo compartment in a commercial cargo jet aircraft. To bound the problem, two analyses of the cargo load column were performed, a static stability analysis and a dynamic analysis.

83-719

An Investigation of the Dynamic Response of a Seismically Stable Platform

B.J. Simmons, F.S. Heming, Jr., and F.E. Morgan

Frank J. Seiler Res. Lab., U.S. Air Force Academy, CO, Rept. No. FJSRL-TR-0007, 80 pp (Aug 1982)

AD-A119 342

Key Words: Isolators, Seismic response

A sub-seismically quiet test platform is currently in development at Holloman AFB, NM. Support to this effort includes structural analyses toward design of a platform which has no structural resonances which affect the active servo frequency band. This report describes the analyses performed to establish credibility of methodology by comparison of experimental test analysis and theoretical analysis of structures. Following technique verification, an experimental analysis of Holloman's prototype platform was conducted and results compared to a theoretical analysis.

83-720

Vibration Isolation System Development for the FB-111 Tail Pod Electronics

R. Dolbeare and G.P. Tillman

Westinghouse Electric Corp., J. Environ. Sci., 25 (6), pp 34-40 (Nov/Dec 1982) 15 figs, 5 tables

Key Words: Vibration isolators, Airborne equipment response, Random vibration

This paper discusses the analysis, design, and testing performed in developing the isolation system for electronics subjected to the extremely severe random vibration environment at the tip of the FB-111 aircraft vertical stabilizer. Included data shows the random vibration response for both hard-mounted and soft-mounted configurations.

83-721

Control of Tilting in Vehicles

I. Čech

Prague, Czechoslovakia, Strojnícky Časopis, 33 (5), pp 543-550 (1982) 8 figs, 1 ref

(In Czech)

Key Words: Suspension systems (vehicles), Active vibration control

The paper deals with models with simple suspension, antiroll bar, simple tilting regulation and active suspension. The best performance is obtained by the active suspension. The vehicle performance is shown by means of characteristics of the acceleration in the mass-center dynamic wheel load and body-wheel displacement in response to impulse both of centrifugal force and uneveness of the road.

83-722

On-Line Control of Nonlinear Flexible Structures

S.F. Masri, G.A. Bekey, and T.K. Caughey

Univ. of Southern California, Los Angeles, CA 90007, J. Appl. Mech., Trans. ASME, 49 (4), pp 877-884 (Dec 1982) 13 figs, 15 refs

Key Words: Multidegree-of-freedom systems, Active vibration control, Buildings, Multistory buildings, Earthquakes

A simple yet efficient method is presented for the on-line control of nonlinear, multidegree-of-freedom systems responding to arbitrary dynamic environments. The control procedure uses pulse generators located at selected positions throughout a given system. The degree of system oscillation near each controller determines the controller's activation time and pulse amplitude. The direct method of Liapunov is used to establish that the response of the controlled nonlinear system is Lagrange stable. Simulation studies of three example systems (conducted with digital and analog computers) demonstrate the feasibility, reliability, and robustness of the proposed active-control method. These systems, which include one with a hysteretic nonlinearity, are structures representative of modern tall buildings; they are subjected to nonstationary random excitation representative of earthquake ground motions.

83-723

Optimal Critical-Mode Control of Building under Seismic Load

J.N. Yang and M.J. Lin

The George Washington Univ., Washington, DC 20052, ASCE J. Engrg. Mech., 108 (EM6), pp 1167-1185 (Dec 1982) 8 figs, 3 tables, 29 refs

Key Words: Active vibration control, Buildings, Seismic excitation, Earthquakes

An analysis of optimal open-loop critical-mode control for tall buildings excited by earthquakes is presented. It is shown that both the active mass damper and the active tendon system are effective in reducing the building response.

TIRES AND WHEELS

83-724

An Analysis of Generating Mechanisms Tire Noise on Dry and Wet Road Surfaces -- Part 1 (Untersuchung der Entstehungsmechanismen von Reifenabrollgeräuschen bei Trockenheit und Nässe -- Teil 1)

W. Liedl, E. Kohler, and R. Eberspacher

Automobiltech Z., 84 (11), pp 543, 544, 547-550, 555, 556 (Nov 1982) 17 figs, 15 refs

(In German)

Key Words: Tires, Interaction: tire-pavement, Noise generation

The state of the art of tire noise on dry road surfaces is presented. Tire vibrations, which are caused by the thread pattern, are identified as the main cause for tire noise on dry surfaces.

BLADES

(Also see No. 716)

83-725

Calculation of the Unsteady Pressure Distribution on an Oscillating Cascade with Thick Profiles and Steady Turning Angle

V. Carstens

Ph.D. Thesis, Georg-August Univ., Fed. Rep. Germany, Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt e.V., Goettingen, Fed. Rep. Germany, Rept. No. DFVLR-FB-81-38, 83 pp (Nov 1981) (Report will also be announced as transl. Esa TT-769)

N82-28600

(In German)

Key Words: Blades, Cascades, Oscillation, Fluid-induced excitation

A method based on Martensen's theory of vorticity layers on a surface in steady flow is derived to calculate the unsteady pressure distribution on a harmonically oscillating plane cascade with an arbitrary profile shape in incompressible flow. After linearizing the basic equations of the initial boundary value problem, which is generally nonlinear, a Fredholm integral equation is developed for the pressure distribution on oscillating blades. Among other characteristic parameters, this equation describes the interaction of steady and unsteady flow. Pressure distributions and aerodynamic coefficients are given for a special case in order to examine the influence of parameters.

83-726

Steam Turbine Blade Design Options: How to Specify or Upgrade

H.G. Naumann

Turbomachinery Consultant, Skillman, NJ, Turbomachinery Symposium, Proc. of the 11th, Texas A&M Univ., College Station, TX, Dec 14-16, 1982, pp 29-50, 51 figs, 15 refs

Key Words: Blades, Steam turbines, Turbine blades, Fatigue life

This paper is intended to familiarize people, who are responsible for rotating equipment, with options in blade designs, especially, with blade specifications, design reviews, inspection and troubleshooting. Mechanisms of causes of blade fatigue and strength deterioration are reviewed. With emphasis on these factors, geometrical and manufacturing differences of blade fastenings, lashings and shrouds are discussed and a qualitative method of identifying stress distributions and stress concentrations in root cross sections is presented.

83-727

Study on Pressure Distribution on Rotor Blades with Three-Dimensional Nonsteady Theory of Compressible Fluid

Zhen Hao Li and Tia Nen Ruan

Acta Aeron. et Astron. Sinica, 3 (2), pp 18-28 (1982)
CSTA No. 629.1-82.14

Key Words: Blades, Propeller blades, Helicopters, Fluid-induced excitation

A calculation of pressure distribution on rotor blades with three-dimensional nonsteady theory of compressible fluid is presented in the case of continuous wake-surface and forward motion of a helicopter at a constant speed. An acceleration potential equation is derived. A fundamental solution of the pressure doublet in an arbitrary motion is given.

83-728

A Simplified Method for Predicting Rotor Blade Airloads

Si Cun Wang and Zhi Xu

Acta Aeron. et Astron. Sinica, 3 (2), pp 1-17 (1982)
CSTA No. 629.1-82.13

Key Words: Blades, Propeller blades, Helicopters, Aerodynamic loads

A simplified approach to the prediction of rotor blade airloads is developed. Relationship of two harmonic induced velocities to lower and same-order harmonic circulation is obtained from the generalized classical vortex theory of the rotor. Based on the blade element theory, a closed form of equation for circulation is established and, by taking the flapping condition into account, simplified formulae for predicting rotor blade airloads are set up. In particular, expressions of flapping coefficients are derived, including the effect of variable induced velocity distribution, in terms of blade parameters and flight parameters only.

BEARINGS

(Also see Nos. 667, 668)

83-729

Calculation of Clearance in the Bearing Contact Zone During Friction (Berechnen des Spaltvolumens in der Lagerstellen-Kontaktzone bei Festkorperreibung)

V.M. Chochlow

Inst. for Machinery Construction, Brjansk, USSR, Maschinenmarkt, 88 (90), pp 1924-1925 (Nov 12, 1982) 2 figs, 2 refs
(In German)

Key Words: Bearings, Lubrication

A new method for the calculation of elastically deformable roughnesses in the contact zone between the bearings, particularly between surfaces of equal roughness, is presented.

83-730
Self-Excited Resonance of Aerostatic Bearings in a Vacuum Environment
Xianluo Fu
Acta Aeron. et Astron. Sinica, 2 (4), pp 70-78 (1981)
CSTA No. 629.1-81.41

Key Words: Bearings, Self-excited vibrations, Resonant response

The cause of instabilities in aerostatic bearing systems operated in a vacuum environment is studied. In order to eliminate this type of self-excited resonance, some pertinent remedies are suggested which can be used to maintain the ambient pressure of the bearing in a range of about 1 ± 0.2 atm. This will improve the performance of the instruments using aerostatic bearings as well as increase the percentage yield of qualified bearings.

GEARS

(Also see No. 837)

83-731
A Computer Solution for the Dynamic Load, Lubricant Film Thickness and Surface Temperatures in Spiral Bevel Gears
C.H.-C. Chao
Ph.D. Thesis, Northwestern Univ., 214 pp (1982)
DA8225887

Key Words: Gears, Bevel gears, Gear teeth, Dynamic structural analysis, Computer-aided techniques

A complete analysis of spiral bevel gears sets is presented. The gear profile is described by the movements of the cutting tools. The contact patterns of the rigid body gears are investigated. The tooth dynamic force is studied by combining the effects of variable teeth meshing stiffness, speed, damping and bearing stiffness. The lubrication performance is also accomplished by including the effects of the lubricant viscosity, ambient temperature and gear speed. A set of numerical results is also presented.

83-732
Dynamic Analysis of a Gear Drive with Backlash (Dynamische Analyse eines Antriebs mit Zahnspiel)
W. Pinnekamp
Zahnraderfabrik Renk AG, Augsburg, Fed. Rep. Germany, Konstruktion, 34 (11), pp 421-427 (1982)
12 figs, 5 refs
(In German)

Key Words: Gears, Torsional vibration

The unloading of teeth caused by torsional vibrations of gear drives is analyzed. An approximation method is presented for a quick calculation of the natural frequencies, lowered by teeth backlash, and the impact excitations of impacting teeth. The procedure is not a substitute for the more reliable numerical simulation technique, but it provides a better understanding of internal relationships and has value as a quick general estimate.

83-733
Study on Welded Structure Gears (3rd Report, Effect of Web Arrangements on Dynamic Loads)
S. Oda, T. Sayama, and T. Koide
Tottori Univ., 4-101 Minami, Koyama-cho, Tottori, Japan, Bull. JSME, 25 (209), pp 1821-1827 (Nov 1982) 9 figs, 1 table, 6 refs

Key Words: Gears, Welded joints

This paper discusses the effect of web arrangement on the dynamic gear-tooth load in welded structure gears. The dynamic loads were measured under various running conditions by making use of a gear testing machine of the power circulating type.

83-734
Effects of Addendum Modification on Bending Fatigue Strength of Spur Gears with Higher Pressure Angle
S. Oda, K. Tsubokura, and C. Namba
Tottori Univ., 4-101 Minami, Koyama-cho, Tottori, Japan, Bull. JSME, 25 (209), pp 1813-1820 (Nov 1982) 20 figs, 4 tables, 9 refs

Key Words: Gears, Fatigue life

A study is presented on the bending fatigue strength and the effects of addendum modification on bending fatigue strength of spur gears with a higher pressure angle made of normalized steel, cast iron and cast steel. The analysis is made regarding the effects of addendum modification on the

true stresses at the root fillet in connection with the worst loading point and also on the bending fatigue strength of gear teeth.

83-735
Bending Strength of Spur Gear Teeth (2nd Report, Estimation of Strength Based on Plastic Strain Amplitude)
T. Tobe and N. Maruyama
Tohoku Univ., Aramaki, Sendai, 980, Japan, Bull. JSME, 25 (209), pp 1797-1804 (Nov 1982) 19 figs, 2 tables, 12 refs

Key Words: Gears, Gear teeth, Steel, Fatigue tests

Bending fatigue tests of spur gear teeth with 8 various tooth fillets made of normalized 0.45% carbon steel are carried out. It is shown that the maximum elastic stress along the tooth fillet is applicable as the rating stress of the fatigue strength in the case of the same rack. The Fe-3Si steel etching technique is used to detect plastic flow around the tooth fillet in fatigue tests.

83-736
Bending Strength of Spur Gear Teeth (3rd Report, Fatigue Strength of Carburized Low Alloy Steel under Varying Loads)
T. Tobe and N. Maruyama
Tohoku Univ., Aramaki, Sendai, 980, Japan, Bull. JSME, 25 (209), pp 1805-1812 (Nov 1982) 6 tables, 13 refs

Key Words: Gears, Gear teeth, Steel, Fatigue tests, Fatigue life

Bending fatigue tests of spur gear teeth made of gas carburized low alloy steel (JIS SCM418) are carried out. The P-S-N curves are obtained and the effect of the residual stress at tooth fillet on fatigue life are examined. Under varying load Miner's rule and the full wave count method gives a good estimation of fatigue life. Back-to-back gear tests are also carried out, and it is shown that the prediction of life by the weakest link model gives good agreement with the test results.

FASTENERS

83-737
Ultrasonic Measurement of Axial Stress
J.S. Heyman and E.J. Chern
NASA Langley Res. Ctr., Hampton, VA 23665, J. Test Eval. (ASTM), 10 (5), pp 202-211 (Sept 1982) 21 figs, 25 refs

Key Words: Fasteners, Bolts, Acoustic techniques, Ultrasonic techniques

Several applications of ultrasonic techniques are gaining acceptance for accurate preload determination of critical fasteners. In this presentation, one class of techniques based on continuous wave ultrasonics is examined in detail, with benefits and limitations discussed as they apply to accurate determination of fastener preload. The theory of acoustic propagation in strained media is reviewed as it applies to bolt geometries.

83-738
Dynamic Effective Young's Modulus of Thin Adhesive Layers in Bonded Joints
N. Ramakrishnan, A.K. De, and S. Suryanarayan
Inst. of Technology, Banaras Hindu Univ., Varanasi-221005, India, J. Test Eval. (ASTM), 10 (5), pp 192-198 (Sept 1982) 11 figs, 5 refs

Key Words: Joints (junctions), Bonded structures, Dynamic modulus of elasticity

To evaluate the dynamic characteristics of bonded structures, it is necessary to know the dynamic characteristics of bonded joints. This paper presents the development of an experimental technique to evaluate the dynamic effective Young's modulus (DEYM) of a thin adhesive layer sandwiched between metallic adherends. Considering the difficulties in measuring the strain across the adhesive layer, it was decided to avoid the measurement of strain in this technique. The joint is introduced in a cantilever beam, which causes its resonant frequency to drop because of the lower modulus of the adhesive layer. An analytical technique has been developed to evaluate its modulus from the drop in resonant frequency.

LINKAGES

83-739
Dynamic Synthesis of a Slider-Crank Mechanism with a Flexibly Attached Slider for Function Generation Incorporating Dwell
J.M. Gulati and A.C. Rao

Government Engrg. College, Jabalpur, India, ASME Paper No. 82-DET-117

Key Words: Linkages, Dynamic synthesis

Simple linkages are incapable of generating functions with dwell and one has to depend upon the cams. However, the cams are costly and noisy in operation. The possibility of obtaining dwell (or near dwell) in simple linkages having flexible elements is investigated and illustrated through numerical examples.

SEALS

83-740

The Non-Linear Response of Hydrodynamic Seals

S.K. Dhagat, R. Sinhasan, and D.V. Singh

Mech. Engrg. Dept., Government Engrg. College, Jabalpur 482011, India, Wear, 82 (2), pp 153-165 (Nov 1, 1982) 17 figs, 10 refs

Key Words: Seals, Rotors, Nonlinear response

The response of a hydrodynamic seal to a specified initial disturbance or to an external excitation that is due to half-speed circular whirl of the rotor was investigated by numerically integrating the linearized and the nonlinear equations of disturbed motion for lateral oscillations of the seal. The seal center motion trajectories obtained are compared. The dynamic load on the seal body that is due to the initial disturbance of either the seal or the specified motion of the rotor is obtained.

CAMS

83-741

Dynamic Synthesis of Cam Systems with N Degrees of Freedom

J. Dominguez, J. Martinez, J.G. Lomas, and L. Arizon

E/T.S. de Ingenieros Industriales, Seville, Spain, ASME Paper No. 82-DET-106

Key Words: Cams, Dynamic synthesis

A numerical method of cam profiles dynamic synthesizing, considering the follower mechanism as a N degrees-of-freedom system, is presented. The objective is to minimize the vibrations of the mechanisms over a range of speeds. The influence of considering one or more degrees-of-freedom in the model and the effect of damping in the synthesized profile are analyzed.

83-742

The Design and Research Works on Increasing the Fatigue Life of the Fuel Injection Pump Cam for High Rated Diesel Engines

Yao Qing Dong, et al

Chinese Internal Combustion Engine Engrg., 3 (1), pp 20-27 (1982)

CSTA No. 621.43-82.03

Key Words: Cams, Pumps, Fatigue life, Diesel engines

This article deals with the fatigue life of the fuel injection pump cam for the high rated diesel engines by means of the classical Hertz theory together with the newly developed elastohydrodynamic theory. Studying the effects of some designing and operating parameters on Hertz pressure and oil film thickness, it points out that the increment of the equivalent radius of the cam curvature as large as possible is very significant to the decrement of its fatigue.

STRUCTURAL COMPONENTS

STRINGS AND ROPES

(Also see No. 873)

83-743

The Sitar String, a Vibrating String with a One-Sided Inelastic Constraint

R. Burridge, J. Kappraff, and C. Morshed

Courant Inst. of Mathematical Sciences, New York Univ., 251 Mercer St., New York, NY 10012, SIAM J. Appl. Math., 42 (6), pp 1231-1251 (Dec 1982) 17 figs, 6 refs

Key Words: Strings, Musical instruments, Flexural vibration

The small transverse motion of a stretched string vibrating against a rigid, inelastic curved obstacle is calculated. This system models the vibration of the strings of certain Indian

musical instruments, the sitar, the tanpura and the vina, where the bridge does not have a sharp edge but is smooth and forms a curved impenetrable obstacle around which the string wraps and unwraps during its vibration. The complete motion of the string plucked at its midpoint is calculated in closed form from the instant it is released to its asymptotic approach to equilibrium.

BARS AND RODS

(Also see No. 817)

83-744

On the Resonant Nonlinear Traveling Waves in a Thin Rotating Ring

C.C. Glynn

General Electric Co., Aircraft Engine Group, Evendale, OH 45215, Intl. J. Nonlin. Mech., 17 (5/6), pp 327-340 (1982) 6 figs, 1 table, 8 refs

Key Words: Rings, Rotating structures, Rods, Curved rods, Wave propagation, Resonant frequencies

Large amplitude, traveling wave motion of an inextensible, linearly elastic, rotating ring is analyzed. Equations governing the planar dynamics of a thin rod, curved in its undeformed state and moving in a horizontal reference frame which rotates about a fixed axis, are obtained via Hamilton's extended principle. The equations are specialized to study the behavior of a rotating circular ring and approximate solutions are obtained near resonance utilizing a perturbation analysis. Undamped free and viscously damped forced traveling wave motion is considered.

83-745

Dynamic Strain of a Longitudinally Vibrating Viscoelastic Rod with an End Mass

T. Pritz

Central Res. and Des. Inst. for the Silicate Industry, 1034 Budapest, Bécsi ut 126/128, Hungary, J. Sound Vib., 85 (2), pp 151-167 (Nov 22, 1982) 10 figs, 5 refs

Key Words: Rods, Viscoelastic properties, Vibrating structures, Harmonic response

The dynamic strain of a viscoelastic rod excited into longitudinal simple harmonic vibraton, a constant amplitude displacement being maintained by a shaker at one end and a mass terminating the other end, is theoretically investigated. The general equation of the strain distribution in the rod is derived by solving the one-dimensional wave equation.

BEAMS

(Also see No. 852)

83-746

Numerical Methods of Parameter Identification for Problems Arising in Elasticity

J.M. Crowley

Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT/CI/NR/82-33D, 136 pp (June 1982)

AD-A119 050

Key Words: Beams, Flexural vibration, Parameter identification technique, Viscous damping, Numerical analysis

Numerical methods for approximate identification or estimation of constant parameters in certain fourth-order partial differential equations (distributed parameter systems) from data are proposed based upon a reformulation of the problem as an abstract equation in a Hilbert space. Projections onto suitable subspaces of splines are used to obtain a semi-discrete approximation which is used to estimate the unknown parameters. Convergence of the approximations is proved using linear semigroup theory and the Trotter-Kato theorem. The proposed methods are applied to estimation of parameters in both the Euler-Bernoulli equation with structural and viscous damping and the Timoshenko equation for transverse vibration of a beam. Numerical results are presented.

83-747

Higher Order Flexural Transients in a Beam

D.P. Thambiratnam

Dept. of Civil Engrg., Natl. Univ. of Singapore, Kent Ridge, Singapore 0511, Intl. J. Engrg. Sci., 21 (1), pp 51-59 (1983) 5 figs, 13 refs

Key Words: Beams, Flexural vibration, Timoshenko theory

The propagation of higher order flexural transients in a Timoshenko beam, subjected to impulsive boundary loads is treated in this paper. The higher order transients are either generated by higher order boundary conditions or induced by homogeneous boundary conditions. The analysis is based on the concept of a wave as a carrier of discontinuities in the field variable and its derivatives. These

discontinuities are determined from a set of recurrence relations which are in turn generated by the use of time-harmonic asymptotic series solutions to the equations of motion. Numerical examples are presented to illustrate the method of solution for higher order transients and the resulting velocity, bending moment and shear force distributions have been computed.

83-748

Design of Beams Subjected to Random Loads

J. Cederkvist
Dept. of Solid Mechanics, The Technical Univ. of Denmark, Lyngby, Denmark, J. Struc. Mech., 10 (1), pp 49-65 (1982) 4 figs, 15 refs

Key Words: Beams, Random excitation, Timoshenko theory, Power spectral density, Cross spectral method

Nonuniform Timoshenko beams subjected to a given stationary random excitation are considered. The general equations relating the spectral density function of the response to the cross spectral density of the load are derived. The optimal shape of the beam is defined as the shape which, for given constant volume of the beam, minimizes the maximum root-mean-square value of the bending stresses in the beam. The shape of the beam is described by a limited number of orthogonal design functions, and their optimal combination is found by sequential linear programming with move limits.

83-749

Theoretical and Experimental Investigation of the Nonlinear Response of the Buckled Beam under Random Excitation

C. Adami
Ph.D. Thesis, Univ. of Southern California (1982)

Key Words: Beams, Random excitation, Nonlinear response

A buckled beam with fixed ends, excited by random uniform pressure uncorrelated in time, is investigated analytically and experimentally. The method of equivalent linearization is used to obtain the mean-square stresses and displacements in buckled and straight beams. Although the maximum displacement can be obtained with the use of only a single degree of freedom model, it is necessary to consider as many as 100 modal functions for accurate determination of the stresses. Results for various combinations of non-dimensional parameters of the problem (buckle amplitude, load power spectral density, axial load) are presented in the form of curves of rms values of maximum displacement versus load power spectral density and of curves of rms values of maximum stress (at edges or center) ver load power spectral density. The objective of the t gram was to obtain data to support and check the ana

83-750

Parameter Estimation in Timoshenko Beam Models

H.T. Banks and J.M. Crowley
Lefschetz Ctr. for Dynamical Systems, Brown Univ., Providence, RI, Rept. No. LCDS-82-14, AFOSR-TR-82-0721, 36 pp (June 1982)
AD-A119 234

Key Words: Beams, Timoshenko theory, Parameter identification technique

Cubic and linear spline-based approximation schemes for models of beams based on the Timoshenko theory are presented. The schemes are used in parameter estimation algorithms; convergence results and numerical findings are reported.

83-751

Dynamic Fracture of Beam under Transverse Load

H. Adeli
The Univ. of Utah, 3012 Merrill Engrg. Bldg., Salt Lake City, UT 84112, ASCE J. Engrg. Mech., 108 (EM6), pp 1025-1035 (Dec 1982) 4 figs, 8 refs

Key Words: Beams, Fracture properties, Bending

The dynamic fracture response of a long beam of brittle elastic material subjected to a transverse time-dependent concentrated load is investigated. If the magnitude of this load is increased to a critical value, a crack will propagate from the tensile side of that cross section. An analysis is presented which relates the transverse force, the bending moment, the axial force, and the crack length at the fracturing section. Consequently, the crack length and other parameters of interest can be determined for any given force. The analysis is applied to several specific examples and typical results are presented.

83-752

Effect of Shear and Rotary Inertia on Dynamic Fracture of a Beam or Plate in Pure Bending

C. Levy and G. Herrmann

Dept. of Mech. Engrg., Stanford Univ., Stanford, CA 94305, J. Appl. Mech., Trans. ASME, 49 (4), pp 773-778 (Dec 1982) 9 figs, 7 refs

Key Words: Beams, Plates, Rotatory inertia effects, Transverse shear deformation effects, Fracture properties

The dynamic fracture response of a long beam of brittle material subjected to pure bending is studied. If the magnitude of the applied bending moment is increased quasi-statically to a critical value, a crack will propagate from the tensile side of the beam. As an extension of previous work, the effect of shear and of rotary inertia on the moment and induced axial load at the fracturing section is included in the present analysis. Thus an improved formulation is presented by means of which the crack length, crack-tip velocity, bending moment, and axial force at the fracture section are determined as functions of time after crack initiation.

83-753

Finite Element Analysis of Dynamically Loaded Homogeneous Viscous Beams

P.D. Griffin and J.B. Martin

Dept. of Civil Engrg., Univ. of Cape Town, Cape Town, South Africa, J. Struc. Mech., 10 (1), pp 93-115 (1982) 6 figs, 2 tables, 10 refs

Key Words: Beams, Viscoelastic properties, Finite element techniques

The paper is concerned with impulsively loaded beams in which the material is treated as homogeneous viscous as an approximation of a rigid-viscoplastic constitutive relation. As opposed to the standard displacement method finite element formulation, where interpolation functions describing the velocity field across elements is given, a mixed formulation is used in which nodal velocities and nodal moments are carried as parameters.

83-754

Experimental and Analytical Study of Internal Beam to Column Connections Subjected to Reversed Cyclic Loading

A.J. Durrani

Ph.D. Thesis, Univ. of Michigan, 300 pp (1982) DA8224939

Key Words: Beam-columns, Cyclic loading, Earthquake simulation

In the experimental part of this study, six full size interior beam-column subassemblages were tested under quasi-static loading which was intended to simulate earthquake input. All specimens were designed following the accepted design philosophy of strong column-weak beam approach. In the analytical part of this study, a hysteretic model for beam-column subassemblages is developed from the hysteretic behavior of specimens observed during testing. The proposed model accounted for pinching of hysteresis loops, stiffness degradation, reduced unloading stiffness and fixed end rotations due to the slippage of bars through the joint. A simple analytical model for computing the maximum story displacements for regular frames is proposed.

CYLINDERS

83-755

Wave Model: Flexible Cylinder in Ocean Waves

H. Brodersen

Sentralinstitutt for Industriell Forskning, Oslo, Norway, Rept. No. ISBN-82-7267-442-4, 78-04-09-9, 57 pp (May 26, 1982)
PB83-100784

Key Words: Cylinders, Underwater structures, Wave forces

A flexible circular cylinder, submerged in water, is allowed to suffer a small deformation as the waves pass. An explicit expression for the velocity potential is obtained in terms of a rapidly converging series. The forces on the cylinder are discussed and the equations of motion are solved under the assumption that the cylinder is not far from being completely rigid.

83-756

A Time-Dependent Green Function and Sway Added Mass of a Rectangular Cylinder at Zero Frequency

Y.K. Chung

Consultant, Chinhae, Korea, J. Ship Res., 26 (4), pp 254-260 (Dec 1982) 3 figs, 11 refs

Key Words: Cylinders, Green function, Underwater structures, Impulse response

The order of passage to the limit in double limiting processes in a sway added-mass problem in water of finite depth is reversible and the double limit is finite. A two-dimensional rectangular cylinder floating in water of finite depth and oscillating in sway motion is considered. When its frequency

and depth-draft ratio approach zero and unity, respectively, the problem involves double limiting processes.

83-757
Wave Model: Oscillating Cylinder in Ocean Waves
T.L. Lindstrom
Sentralinstitutt for Industriell Forskning, Oslo, Norway, Rept. No. ISBN-82-7267-347-9, 78-04-09-6, 77 pp (May 15, 1981)
PB83-100602

Key Words: Cylinders, Vibrating structures, Wave forces

The author considers a submerged, circular cylinder moving in small perturbations round an equilibrium position, and studies its impact on water waves. An explicit expression for the velocity potential is obtained in terms of a rapidly converging series.

COLUMNS
(Also see No. 852)

83-758
Bounds on Earthquake Response of Elastic Columns
G. Ahmadi and N. Mostaghel
Dept. of Mech. and Industrial Engrg., Clarkson College, Potsdam, NY 13676, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (6), pp 769-777 (Nov/Dec 1982) 3 figs, 18 refs

Key Words: Columns, Elastic properties, Earthquake response, Ground motion, Lyapunov functions

The dynamics of an elastic column subjected to vertical as well as horizontal ground acceleration during an earthquake strong motion is considered. The Liapunov method of stability analysis is employed and several bounds on the maximum lateral displacement and bending stress are obtained and discussed.

FRAMES AND ARCHES
(Also see No. 868)

83-759
Dynamic Stability Boundaries for Shallow Arches
W.E. Gregory, Jr. and R.H. Plaut
CASDE Corp., Alexandria, VA 22303, ASCE J. Engrg. Mech., 108 (EM6), pp 1036-1050 (Dec 1982) 17 figs, 1 table, 10 refs

Key Words: Arches, Impulse response, Step response, Snap through problems

The interactive effects of multiple dynamic loads on the snap-through instability of shallow elastic arches are investigated. Impulse loads and step loads of infinite duration are considered. Critical load combinations, based on the Budiansky-Roth criterion, are computed numerically and plotted as interaction curves. Curves of constant maximum response are also presented. The results for step loads are compared to the static critical loads, while the critical impulse loads are compared to some lower bounds.

PLATES
(Also see No. 752)

83-760
The Extension of Component Mode Synthesis for the Analysis of Plate Type Structures
D.J. Drag
Ph.D. Thesis, Univ. of California, Los Angeles, 518 pp (1982)
DA8225578

Key Words: Plates, Component mode synthesis

An extension of the previous concepts of modal synthesis is developed for the analysis of plate type structures. The criteria needed to formulate this modal synthesis extension, the methodology to satisfy this criteria, and the development of a finite element, or super element, for use in analysis are addressed in this research work. The selected method of modal synthesis is the method of component mode synthesis and is commonly referred to as the fixed-interface component mode method.

83-761
Vibration of Flexible Plate on Viscoelastic Medium
M. Iguchi and J.E. Luco
Faculty of Sci. and Engrg., Science Univ. of Tokyo, Noda City, Japan, ASCE J. Engrg. Mech., 108 (EM6), pp 1103-1120 (Dec 1982) 9 figs, 17 refs

Key Words: Plates, Circular plates, Viscoelastic foundations, Interaction: soil-structure

The dynamic response of a massless flexible circular plate with a rigid core supported on a layered viscoelastic half-space and subjected to harmonic vertical and rocking excitation is studied. The mixed boundary-value problem for the case of relaxed contact conditions between the plate and the half-space is reduced to Fredholm integral equations of the second kind which are solved numerically. The effects of flexibility of the plate on the force-displacement relationship, on the motion of different points on the plate, and on the distribution of contact stresses beneath the plate are studied numerically.

83-762

Vibration and Stability of a Variable Thickness Annular Plate Subjected to a Torque

T. Irie, G. Yamada, and M. Tsujino

Dept. of Mech. Engrg., Hokkaido Univ., Sapporo 060, Japan, J. Sound Vib., 85 (2), pp 277-285 (Nov 22, 1982) 5 figs, 6 tables, 12 refs

Key Words: Plates, Annular plates, Variable cross section, Torque

The free vibration and stability of a variable thickness annular plate subjected to a torque are analyzed by the Ritz method. For this purpose, the transverse deflection of an annular plate is written in a series of the deflection functions of a uniform thickness annular plate without the action of a torque. The kinetic and strain energies of the plate are evaluated analytically and the frequency equation of the plate is derived by the conditions for a stationary value of the Lagrange functional. The present method is applied to annular plates with two types of radial thickness variation, power law and exponential, and the natural frequencies (the frequency parameters) and the divergence torques are calculated numerically, from which the effects of the varying thickness, inner/outer radii ratio and edge conditions are studied.

83-763

Rayleigh-Ritz Vibration Analysis of Rectangular Mindlin Plates Subjected to Membrane Stresses

O.L. Roufaeil and D.J. Dawe

Dept. of Civil Engrg., Univ. of Birmingham, Birmingham B15 2TT, UK, J. Sound Vib., 85 (2), pp 263-275 (Nov 22, 1982) 6 figs, 3 tables, 15 refs

Key Words: Plates, Rectangular plates, Flexural vibration, Mindlin theory, Rayleigh-Ritz method

A previously developed analysis of the flexural vibration of isotropic rectangular plates is extended to include the presence of a membrane stress system. The method of analysis is the Rayleigh-Ritz method and Mindlin plate theory is used which takes into account effects which are disregarded in the classical plate theory. Numerical results are presented for a number of types of plate and of applied stress which show the manner of variation of the frequencies of vibration as the intensity of stress changes.

83-764

Sampling Statistics for Vibrating Rectangular Plates

R.V. Waterhouse, A.F. Kilcullen, and J.E. Brooks

David Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD 20084, J. Acoust. Soc. Amer., 72 (6), pp 1863-1869 (Dec 1982) 12 figs, 9 refs

Key Words: Plates, Rectangular plates, Flexural vibration, Resonant frequencies, Probability density function

A thin, uniform, rectangular, elastic plate is freely supported in air, and driven so that it vibrates flexurally at a resonance frequency. The modal function, which describes the vibrational displacement over the surface of the plate, is approximated as the product of two sine functions. Estimates of known precision are made of the mean vibrational level of the plate. Experimental results are given for a steel plate measuring 4 ft x 3 ft x 1/4 in., resonating at a single frequency. Also considered are cases where two overlapping modes are excited at a given frequency.

83-765

Axisymmetric Elastic Waves Excited by a Point Source in a Plate

R.L. Weaver and Yih-Hsing Pao

Cornell Univ., Ithaca, NY 14853, J. Appl. Mech., Trans. ASME, 49 (4), pp 821-836 (Dec 1982) 10 figs, 1 table, 27 refs

Key Words: Plates, Elastic waves, Point source excitation, Method of superposition

The response of an infinite elastic plate to dynamic loading is presented by the method of superposition of normal modes, a method particularly appropriate in the intermediate and far field. The method is compared with the method of integral transforms. Explicit expressions are given for the case of loading by a concentrated vertical step force. These expressions are evaluated numerically over a range of distances from 4 to 40 plate thicknesses. The numerical results

are compared with qualitative stationary phase analyses and with the exact results of generalized ray theory.

83-766

Shock Response of Internally Damped Laminated Plates

A.S. Grover and A.D. Kapur
Dept. of Mech. Engrg., Punjab Engrg. College, Chandigarh, India, Strojnícky Časopis, 33 (5), pp 513-527 (1982) 9 figs, 15 refs

Key Words: Plates, Layered materials, Internal damping, Shock response

Shock response of a simply supported three-layer internally damped laminated plate subjected to half-sine pulse acceleration are analyzed taking into account the effect of transverse inertia only. The influence of various geometrical and physical parameters on the shock response behavior of the internally damped sandwich plate are investigated.

83-767

Spectra of Transient Waves in Elastic Plates

R.L. Weaver and Yih-Hsing Pao
Dept. of Theoretical and Appl. Mech., Cornell Univ., Ithaca, NY 14853, J. Acoust. Soc. Amer., 72 (6), pp 1933-1941 (Dec 1982) 7 figs, 11 refs

Key Words: Plates, Elastic waves, Fast Fourier transform, Asymptotic approximation, Acoustic emission, Sound source identification

Frequency spectra of transient Rayleigh-Lamb waves in a plate are evaluated by two methods, a direct numerical integration (FFT), and an asymptotic calculation of the theoretical responses. A simple formula is developed for the interference pattern of the spectra of two or more modes of progressing waves, which is then applied to interpret the complex frequency spectra of the waves in a plate over a wide range of frequency. These interpretive techniques may be applicable to source characterization of acoustic emission.

SHELLS

(Also see Nos. 703, 868)

83-768

Stability and Vibrations of Compressed, Aeolotropic, Composite Cylindrical Shells

J.B. Greenberg and Y. Stavsky
Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Appl. Mech., Trans. ASME, 49 (4), pp 843-847 (Dec 1982) 7 figs, 17 refs

Key Words: Shells, Cylindrical shells, Composite structures, Fiber composites

A general method of solution, based on a complex finite Fourier transform, is adopted for the stability and vibration analysis of compressed, aeolotropic, composite cylindrical shells. A major feature of the solution method is its ability to handle both uniform and nonuniform conditions that hold at the boundaries of finite-length cylindrical shells.

83-769

Axisymmetric Vibrations of Conical Shells with Variable Thickness

S. Takahashi, K. Suzuki, E. Anzai, and T. Kosawada
Yamagata Univ., Yonezawa, Japan, Bull. JSME, 25 (209), pp 1771-1780 (Nov 1982) 13 figs, 19 refs

Key Words: Shells, Conical shells, Variable cross section, Axisymmetric vibrations

The axisymmetric free vibrations of truncated conical shells are analyzed by means of an improved shell theory. The equations of vibration are solved exactly by a solution in series for a conical shell with linearly varied thickness along its axis and the effects of boundary conditions, thickness and semi-vertex angle on the natural frequencies are investigated. This theory is compared with Mindlin's circular plate theory and Mirsky's cylindrical shell theory.

RINGS

83-770

Free Out-of-Plane Vibration of a Ring Elastically Supported at Several Points

T. Irie, G. Yamada, and H. Okada
Hokkaido Univ., Kita-13, Nishi-8, Kita-ku, Sapporo, 060 Japan, J. Appl. Mech., Trans. ASME, 49 (4), pp 854-860 (Dec 1982) 6 figs, 1 table, 12 refs

Key Words: Rings, Elastic foundations, Natural frequencies, Mode shapes

An analysis is presented for free out-of-plane vibration of a circular ring elastically supported against deflection, rotation,

and torsion at several points located at equal angular intervals. The equations of out-of-plane vibration of the ring are expressed as a matrix differential equation by using the transfer matrix.

PIPES AND TUBES

(Also see No. 868)

83-771

Nondestructive Testing of Pipes and Tubes. 1976 - September 1982 (Citations from the Energy Data Base)

NTIS, Springfield, VA, 200 pp (Sept 1982)
PB82-875501

Key Words: Tubes, Pipes (tubes), Nondestructive tests, Bibliographies

This bibliography contains 198 citations concerning the nondestructive techniques for testing or examining a wide variety of pipes and tubes for the detection of flaws or defects which affect their mechanical properties.

83-772

Nondestructive Testing of Pipes and Tubes. 1970 - September, 1982 (Citations from the NTIS Data Base)

NTIS, Springfield, VA, 143 pp (Sept 1982)
PB82-875493

Key Words: Tubes, Pipes (tubes), Nondestructive tests, Bibliographies

This bibliography contains 111 citations concerning the nondestructive techniques for testing or examining a wide variety of pipes and tubes for the detection of flaws or defects which affect their mechanical properties.

83-773

Experiment and Analysis of Instability of Tube Rows Subject to Liquid Crossflow

S.S. Chen and J.A. Jendrzejczyk
Argonne Natl. Lab., 9700 S. Cass Ave., Argonne, IL 60439, J. Appl. Mech., Trans. ASME, 49 (4), pp 704-708 (Dec 1982) 9 figs, 1 table, 7 refs

Key Words: Tubes, Fluid-induced excitation, Tube arrays

A tube array subjected to crossflow may become unstable by either one or both of the two basic mechanisms: velocity mechanism and displacement mechanism. An experimental and analytical study of tube rows in liquid crossflow is performed to verify the existence and transition between the two mechanisms at the intermediate values ofmass-damping parameter. Experimental data and analytical results are found to be in good agreement.

DUCTS

83-774

Pressure Transfer Function of a JT15D Nozzle Due to Acoustic and Convected Entropy Fluctuations

J.H. Miles and E.A. Krejsa
NASA Lewis Res. Ctr., Cleveland, OH 44135, J. Acoust. Soc. Amer., 72 (6), pp 2008-2019 (Dec 1982) 9 figs, 1 table, 25 refs

Key Words: Ducts, Sound transmission

An acoustic transmission matrix analysis of sound propagation in a variable area duct with and without flow is extended to include convected entropy fluctuations. The boundary conditions used in the analysis are a transfer function relating entropy and pressure at the nozzle inlet and the nozzle exit impedance. The nozzle pressure transfer function calculated with this analysis is compared with JT15D turbofan engine nozzle data.

83-775

The Decaying Flow Technique: A Method for the Rapid Acquisition of Data Relating to Regenerated Noise in Ventilation Systems

A.U. Ukpoho and D.J. Oldham
Dept. of Bldg. Science, Univ. of Sheffield, Western Bank, Sheffield S10 2TN, UK, Noise Control Engrg., 19 (3), pp 86-92 (Nov/Dec 1982) 7 figs, 9 refs

Key Words: Ducts, Ventilation, Noise generation, Data processing

A technique is described in which data on noise regenerated by air duct elements can be rapidly acquired. The method is

based upon measuring the sound power generated by elements subjected to a decaying flow. The system requires a large plenum which can be pressurized by a fan and which will, on switching off the fan, discharge air through a test element at a gradually decreasing velocity so that sound power versus air velc :ity data can be acquired during the decay process. To achieve the full potential of the system, a microcomputer based data acquisition method is desirable.

83-776

Sound Propagation in Multistage Axial Flow Turbomachines

K.E. Heinig

Motoren- und Turbinen-Union München GmbH, W. Germany, AIAA J., 21 (1), pp 98-105 (Jan 1983) 11 figs, 12 refs

Key Words: Ducts, Turbomachinery, Sound propagation, Aircraft engines

A method is described for determining the sound propagation in multistage turbomachines. It is applicable to turbomachines which have nonuniform annular ducts carrying a mean flow with a swirling component. Comparison with measurements and the results from other theories show good compatibility. A computational study illustrates the influence of the swirling flow component and other parameters on the sound propagation. Numerical results are presented which indicate a strong acoustic coupling of the cascades.

83-777

Modal Power Distribution in Ducts at High Frequencies

S.M. Baxter and C.L. Morfey

Univ. of Southampton, Southampton, UK, AIAA J., 21 (1), pp 74-80 (Jan 1983) 4 figs, 5 tables, 10 refs

Key Words: Ducts, Acoustic linings, Sound attenuation, Modal analysis

Sound attenuation in a lined duct depends on, among other factors, the distribution of power among the propagating modes. Up to now, the modal power distribution has not been measurable because existing measurement techniques have involved resolving for all the modes cut on at a given frequency. At high frequencies such techniques become impractical. New theoretical results are given about the high-frequency asymptotic behavior of duct sound fields. Results are based on a description in which the power distribution is treated as a continuous function of modal coordinates. The results lead to a new experimental technique for investigating the power distribution. A finite set of cross-spectral density measurements is used to estimate the distribution as a function of modal coordinates.

83-778

Acoustic Waves in a Cylindrical Duct with Periodically Varying Cross Section

A. Bostrom

Inst. of Theoretical Physics, Chalmers Univ. of Tech., S-412 96 Goteborg, Sweden, Wave Motion, 5 (1), pp 59-67 (Jan 1983) 7 figs, 12 refs

Key Words: Ducts, Variable cross section, Elastic waves

The null field approach is used to study the propagation of acoustic waves in a rotationally symmetric hard-walled duct with a periodically varying cross section. For a radius that varies sinusoidally along the axial distance, numerical computations give the axial wave number and the passbands and stopbands of the modes of the duct.

83-779

Steady and Unsteady Transonic Flow in a Duct with a Sudden Enlargement

J.S. Anderson and G.E.A. Meier

Max-Planck-Inst. fuer Stroemungsforschung, Goettingen, Fed. Rep. Germany, Rept. No. MPIS-1/1982/ ISSN-0436-1199, 73 pp (Feb 1982)

N82-28599

Key Words: Ducts, Shock wave propagation

Flow structure in a rectangular or circular duct, following an abrupt change in section, were studied. Density measurement was with a Mach-Zehnder interferometer and of velocity with a laser Doppler anemometer. The flow structure was controlled either by a single normal shock wave or by a series of reflected oblique shocks. An empirical approach is adopted to the task of determining the characteristic base pressure oscillation frequency and of estimating the harmonic which occurs. The phase relationship between the pressure downstream at the wall and the base pressure was investigated.

BUILDING COMPONENTS

(Also see No. 677)

83-780

Measurement of Background Noise in Sound-Insulated Rooms

P.K. Moller

Acoustics Lab., Tech. Univ. of Denmark, DK-2800, Lyngby, Denmark, J. Sound Vib., 85 (2), pp 143-150 (Nov 22, 1982) 7 figs, 1 table, 4 refs

Key Words: Rooms, Noise measurement

Problems concerning measurement of stationary background noise levels below the dynamic limits of normal transducers are studied. The use of very sensitive large transducers is possible, but in general is restricted to rather low frequencies due to their extreme directional characteristics. Thus a 10-inch transducer may be used up to approximately 250 Hz. Two-transducer approaches based on correlation techniques cover a much wider frequency range because ordinary small transducers are applicable.

83-781

On Reflection of a Planar Solitary Wave at a Vertical Wall

H.P. Meneses and A.T. Chwang

Inst. of Hydraulic Res., Iowa Univ., Iowa City, IA, Rept. No. IIHR-251, 35 pp (Aug 1982)
PB83-105247

Key Words: Walls, Wave reflection

The reflection of a planar solitary wave at a vertical wall is investigated by solving the Boussinesq equations analytically as well as numerically. The analytical solution is obtained by means of the inner-outer expansions technique, while the numerical solution is based on a finite-difference scheme. The maximum wave amplitude at the wall and the time at which this maximum amplitude is reached are presented.

83-782

Development Report for the 10 KW Sound Attenuation Program (Preproduction 'F' Kit)

G.L. Butzke

Turbomach. Div., Solar Turbines, Inc., San Diego, CA, Rept. No. ERR-0195, 55 pp (Dec 2, 1981)
AD-A118 810

Key Words: Enclosures, Sound attenuation, Gas turbine engines

This final report covers the program undertaken to develop an acoustic enclosure for the 10 KW 60 Hz GTED generator set. The enclosure was designed to meet the performance requirements of category F of MIL-STD-1474. Tests were conducted to determine any detrimental effects of running the gas turbine engine inside a closed environment. Tests were also conducted to determine the acoustical characteristics of the enclosed package and a comparison done with the standard 10 KW 60 Hz generator set to determine the attenuation provided by the acoustic enclosure.

83-783

Scattering of Acoustic Waves by Rigid Cylindrical Objects with Sharp Corners

V.K. Varadan, V.V. Varadan, S.J. Tsao, and W.G. Neubauer

Wave Propagation Group, Dept. of Engrg. Mech., Ohio State Univ., Columbus, OH, J. Acoust. Soc. Amer., 72 (6), pp 1957-1964 (Dec 1982) 14 figs, 1 table, 14 refs

Key Words: Acoustic scattering, Cylinders

The T-matrix or Null Field approach is employed for studying scattering of acoustic waves by rigid cylindrical obstacles with sharp corners. A piecewise basis function is used to represent the surface field. The algebraic system of equations obtained from the resulting integral equations is solved for computing the surface and farfield amplitudes. Numerical results are presented for backscattering and bistatic scattering cross sections for square and intersecting circular cross sections and are compared with those obtained for smooth cross section, such as elliptical cross sections. Wavelengths down to one fifth of the maximum dimension of the section are considered.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 819, 866, 867)

83-784

Scattering by Slender Bodies of Revolution

M.C. Junger

Cambridge Acoustical Associates, Inc., 54 Rindge Avenue Extension, Cambridge, MA 02140, J. Acoust. Soc. Amer., 72 (6), pp 1954-1956 (Dec 1982) 2 figs, 7 refs

Key Words: Acoustic scattering, Bodies of revolution, Baffles

The pressure scattered by slender bodies of revolution irradiated by a plane wave at "beam aspect" is formulated in a manner which relaxes the assumptions underlying the Kirchhoff analysis. While the latter stipulates that area elements scatter as though located in planar baffles, the present theory assumes that the baffles are cylindrical; i.e., that one rather than two radii of curvature is infinite. The theory gives good results in the resonance and Rayleigh regions as well as in the short-wavelength limit even for bodies whose aspect ratio is only two.

83-785

A Least-Square Iterative Technique for Solving Time-Domain Scattering Problems

G.C. Herman and P.M. Van Den Berg

Delft Univ. of Tech., Dept. of Electrical Engrg., Lab. of Electromagnetic Res., P.O. Box 5031, 2600 GA Delft, The Netherlands, J. Acoust. Soc. Amer., 72 (6), pp 1947-1953 (Dec 1982) 8 figs, 13 refs

Key Words: Acoustic scattering, Time domain method, Least squares method

An alternative method for the numerical solution of time-domain integral equations pertaining to three-dimensional, transient scattering problems is developed and applied to two representative acoustic scattering configurations. It is based on the iterative minimization of an integrated square error.

83-786

Recent Investigations of the Propagation of Finite Amplitude Multi-Dimensional Acoustic Waves

J.H. Ginsberg

Georgia Inst. of Tech., Atlanta, GA 30332, Shock Vib. Dig., 14 (12), pp 17-21 (Dec 1982) 1 fig, 29 refs

Key Words: Wave propagation, Sound waves, Reviews

Phenomena are described that arise in multi-dimensional systems in which wave intensity is not uniform transverse to the direction of propagation. Use of the direct method and applications of integral transforms in the analysis of wave propagation are described.

83-787

Normal Mode Theory: The Role of the Branch-Line Integral in Pedersen-Gordon Type Models

M. Hall

Code 712, Naval Ocean Systems C*r., San Diego, CA 92152, J. Acoust. Soc. Amer., 72 (6), pp 1978-1988 (Dec 1982) 7 figs, 2 tables, 35 refs

Key Words: Underwater sound, Normal modes

The acoustic field at the cutoff frequency of a shallow water channel is calculated using the Pedersen-Gordon normal mode model. As the (negative) sound-speed gradient in the terminal layer approaches zero, the values of the acoustic field at various positions are found to approach well defined limits.

83-788

Experimental Research on Perforated Acoustic Liners in Turbojet Engine Afterburners

Xuobin Ou and Guoxiong Ni

Acta Aeron. et Astron. Sinica, 2 (4), pp 52-59 (1981) CSTA No. 629.1-81.39

Key Words: Turbojet engines, Acoustic linings, Hole-containing media

The reasonable choice of construction parameters for perforated acoustic liners in turbojet engine afterburners is investigated. The perforated acoustic liner should have as much as possible high oscillation absorptivity in a quite wide frequency range by increasing the volume of acoustic resonant space and perforated area ratio of the shield. The smooth geometry of the liner can make the secondary flow uniform around the outer chamber shell and, therefore, avoid high temperature stripes proceeding from the gas separated-flow vortex at the wave valley on the perforated acoustic liner.

83-789

Time Variations in Urban Traffic Noise. A Case Study in Akron, Ohio

V.R. Harnapp and A.G. Noble

The Univ. of Akron, Akron, OH, S/V, Sound Vib., 16 (12), pp 20-22 (Dec 1982) 5 figs, 1 table, 1 ref

Key Words: Traffic noise, Noise measurement

An intense 7-day monitoring period, in which 22,500 noise measurements were taken in central Akron, OH, sought to establish a standard noise profile of urban traffic noise. The study confirmed the regularity of noise variations with the passage of time.

83-790

Field Assessment of Highway Noise Barriers

J. Desormeaux

Ontario Hydro, Pickering, Ontario, Canada, S/V, Sound Vib., 16 (12), pp 23-25 (Dec 1982) 3 figs, 3 refs

Key Words: Traffic noise, Noise reduction, Noise barriers

This article describes various aspects of field assessment of noise barriers such as influence of environmental factors and traffic variables, site selection, and techniques to analyze measured data. A simple practical procedure for the field assessment of barrier performance is described.

SHOCK EXCITATION

(Also see No. 779)

83-791

Free-Field Response from Inclined SH-Waves and Love-Waves

J.P. Wolf and P. Obernhuber

Electrowatt Engineering Services, Ltd., 8022 Zurich, Switzerland, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (6), pp 823-845 (Nov/Dec 1982) 28 figs, 18 refs

Key Words: Seismic waves, Wave propagation, Interaction: soil-structure, Seismic design

To identify the key features of the free-field response for antiplane motion, a vast parametric study is performed, varying the location of the control point, the nature of the wave pattern and the site properties. Harmonic and transient seismic excitations for a site consisting of a layer on bedrock and an actual soft site and a rock site are investigated.

83-792

Free-Field Response from Inclined SV- and P-Waves and Rayleigh-Waves

J.P. Wolf and P. Obernhuber

Electrowatt Engrg. Services Ltd., 8022 Zurich, Switzerland, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (6), pp 847-869 (Nov/Dec 1982) 22 figs, 3 tables, 5 refs

Key Words: Seismic waves, Wave propagation, Interaction: soil-structure

To identify the key features of the free-field response for inplane motion, a vast parametric study is performed, varying the location of the control point, the nature of the wave pattern and the site properties. Harmonic excitation for a site consisting of a layer on bedrock is investigated.

83-793

Pseudospectral Solution of One Dimensional and Two Dimensional Inviscid Flows with Shock Waves

L. Sakell

Naval Res. Lab., Washington, DC, Rept. No. NRL-MR-4892, 34 pp (Aug 6, 1982)
AD-A118 163

Key Words: Shock wave propagation

A new approach is presented for the utilization of pseudospectral techniques for the solution of inviscid flows with shock waves using the full Euler equations of motion. Artificial viscosity is applied together with low pass spectral filtering to damp out pre and post cursor numerical oscillations. Solutions are presented for the one dimensional propagating shock wave problem and for two dimensional supersonic wedge flows.

83-794

The Autonomy of Sonic Shock-Waves. An Application to Detonations (Sur l'autonomie des ondes de choc à état aval sonique. Cas de la détonation)

L. Brun

Centre d'Études de Vaujours, B.P. no. 7, 93270 Sevran, France, J. de Mecanique, 1 (4), pp 623-644 (1982) 10 figs, 20 refs
(In French)

Key Words: Shock waves

The local study of the field of characteristic lines within the perfect-fluid model allows one to correlate the upholding

and curvature of a sonic shock-wave. The global study points out the fact that a sonic regime is not the limit of subsonic regimes: in cylindrical and spherical geometry the flow comprises an autonomy domain inside which the sequence of states met by the sonic front completely determines the solution. The example of the Chapman-Jouguet detonation is examined in greater detail and the significance of the self-similar solution of Zel'dovitch-Taylor is assessed.

VIBRATION EXCITATION

83-795

Quasiperiodic Bifurcation in Nonlinearly-Coupled Oscillators Near a Point of Strong Resonance

P.H. Steen and S.H. Davis

Dept. of Chemical Engrg., Stanford Univ., Stanford, CA 94305, SIAM J. Appl. Math., 42 (6), pp 1345-1368 (Dec 1982) 8 figs, 18 refs

Key Words: Oscillators, Natural frequencies, Resonant response

A pair of uncoupled linear oscillators have natural frequencies δ and γ and damping coefficient proportional to λ. When they are coupled through a class of cubic nonlinearities, the null solution bifurcates at $\lambda = \lambda_c$. The bifurcating solutions are analyzed near the strong resonance. The resulting approximation is uniformly valid.

83-796

Perturbation Theories for Sine-Gordon Soliton Dynamics

M. Salerno, M.P. Soerensen, O. Skovgaard, and P.L. Christiansen

Lab. of Appl. Mathematical Physics, The Technical Univ. of Denmark, DK-2800 Lyngby, Denmark, Wave Motion, 5 (1), pp 49-58 (Jan 1983) 11 figs, 12 refs

Key Words: Wave propagation

Three recent perturbation assumptions for soliton dynamics on Josephson junctions are compared with direct numerical integrations of the perturbed sine-Gordon equation. The McLaughlin-Scott theory yields the better prediction of soliton transmission or pinning at a microshort in presence of loss and bias without or with surface resistance loss.

83-797

Aerodynamics of an Airfoil with a Jet Issuing from Its Surface

D.A. Tavella and K. Karamcheti

NASA Ames Res. Ctr., Moffett Field, CA, Rept. No. NASA-TM-84825, 93 pp (May 1982)

N82-29267

Key Words: Airfoils, Aerodynamic characteristics

A simple, two dimensional, incompressible and inviscid model for the problem posed by a two dimensional wing with a jet issuing from its lower surface is considered and a parametric analysis is carried out to observe how the aerodynamic characteristics depend on the different parameters. The mathematical problem constitutes a boundary value problem where the position of part of the boundary is not known a priori. A nonlinear optimization approach was used to solve the problem.

83-798

Air Foils: Drag, Turbulent Flow, and Vibration Reduction. 1973 - September 1982 (Citations from Information Services in Mechanical Engineering Data Base)

NTIS, Springfield, VA, 209 pp (Sept 1982)

PB82-875899

Key Words: Airfoils, Vibration control, Bibliographies

This bibliography contains 252 citations concerning the design of airfoils for the minimization of drag and turbulent flow. Topics include parameters affecting the formation of vortices, excessive vibration, and fuel consumption.

83-799

Unsteady Boundary Layer Due to an Oscillating Free Stream vs. an Oscillating Model

D.E. Wilson

College of Engrg., South Carolina Univ., Columbia, SC, Rept. No. AFOSR-TR-82-0675, 59 pp (June 1982)

AD-A118 591

Key Words: Airfoils, Flexural vibration

The objective of this investigation is to calculate the unsteady boundary layer induced on a thin airfoil by two distinct

mechanisms. First, a uniform upstream flow approaches an airfoil which is undergoing a periodic transverse oscillation of specified frequency and amplitude with respect to the wind tunnel. Secondly, a uniform upstream flow approaches the same airfoil which is fixed with respect to the wind tunnel but is now subjected to transverse oscillating flow.

83-800

Unsteady Newton-Busemann Flow Theory. Part III. Frequency Dependence and Indicial Response

W.H. Hui
Dept. of Appl. Mathematics, Univ. of Waterloo, Ontario, Canada, Aeronaut. Quart., 33 (4), pp 313-330 (Nov 1982) 8 refs

Key Words: Airfoils, Flutter

A complete unsteady Newton-Busemann flow theory, including centrifugal force corrections, was successfully applied to study the dynamical stability of oscillating aerofoils and bodies of revolution. The present paper extends these results, which are restricted to the first order in frequency, to general frequencies that may be applicable to flutter analysis as well. The new results are used to investigate the behavior of the indicial response functions in unsteady flow at very high Mach numbers.

83-801

Vortex Shedding from a Cylinder and the Meaning of the Corresponding Strouhal Number

J. Novak
Natl. Res. Inst. for Machine Design, Prague 9-Běchovice, Czechoslovakia, Strojnícky Časopis, 33 (5), pp 627-642 (1982) 4 figs, 1 table, 15 refs
(In Czech)

Key Words: Vortex shedding, Cylinders, Vibrating structures, Submerged structures, Fluid-induced excitation

Vortex shedding from both a vibrating and a non-vibrating cylinder placed in the liquid flow or moving through stationary liquid is investigated. Vortex-excited resonant vibrations as well as forced vibrations are considered, in both cases under synchronization. The use of Karman theoretical formula for mean drag force calculation and Sallet formula for the calculation of lift force amplitude is discussed. Results of calculation of the coefficients of these forces in a circular cylinder are given.

83-802

Optimal Control of Vibration by Wind Force on Running Vehicle

K. Yoshida, T. Shimogo, and S. Onoda
Faculty of Science and Tech., Keio Univ., 14-1, Hiyoshi 3-Chome, Kohoku-Ku, Yokohama 223, Japan, Bull. JSME, 25 (209), pp 1789-1796 (Nov 1982) 19 figs, 10 refs

Key Words: Vibration control, Ground vehicles, Railroad trains, Wind forces

A high speed running vehicle relatively receives an air flow. In this study, wind was applied on the running vehicle as the source of a control force for a vibrating system in the vehicle. An optimal control system equipped with wind was designed by applying the optimal control theory to a single-degree-of-freedom system subjected to the disturbance of a random process with a dominant frequency on the assumption of a stationary lift.

83-803

Integral Representations for Elastodynamic Edge Diffraction

A.K. Gautesen
Ames Lab. and Dept. of Mathematics, Iowa State Univ., Ames, IA 50011, Wave Motion, 5 (1), pp 69-82 (Jan 1983) 11 refs

Key Words: Wave diffraction, Wave propagation, Elastic waves

For the problem of diffraction by a plane obstacle of a point force singularity, a line integral representation for derivatives of the field is derived. From this representation a line integral of the field is obtained which is asymptotically equivalent to Keller's theory of geometrical edge diffraction as developed for elastic wave propagation by Achenbach, Gautesen, and McMaken.

83-804

A Note on the Mean Circulation in Standing Waves

E.W. Haddon and N. Riley
Univ. of East Anglia, Norwich, UK, Wave Motion, 5 (1), pp 43-48 (Jan 1983) 4 figs, 9 refs

Key Words: Wave propagation

The time-mean motion in two dimensions induced by small-amplitude standing waves on liquid of finite depth is con-

sidered. Solutions are obtained by numerical integration of the Navier-Stokes equations of finite values of an appropriately defined Reynolds number.

83-805

Signal Velocity for Transient Waves in Linear Dissipative Media

F. Mainardi
Dept. of Mathematics, Univ. of Bologna, 40127 Bologna, Italy, Wave Motion, 5 (1), pp 33-41 (Jan 1983) 4 figs, 10 refs

Key Words: Wave propagation, Periodic response

The concept of signal velocity for transient sinusoidal waves in linear dissipative media is discussed. The method of the steepest descent path is used to show whether the signal velocity may equal the group velocity or the phase velocity.

83-806

Instability of Parametric Dynamic Systems with Non-Uniform Damping

K. Takahashi
Dept. of Civil Engrg., Nagasaki Univ., Nagasaki, Japan, J. Sound Vib., 85 (2), pp 257-262 (Nov 22, 1982) 2 figs, 2 tables, 7 refs

Key Words: Dynamic systems, Harmonic balance method, Resonant response, Damping effects

A unified way of looking at parametric and combination resonances in systems with periodic coefficients and different amounts of damping in the various modes of vibration is presented. The stability boundaries of the coupled Mathieu equations are determined by the harmonic balance method, Fourier series with periods 2T and T being assumed. The basic characteristics of the solution are discussed and the method is applied to multiple-degree-of-freedom dynamic systems.

MECHANICAL PROPERTIES

DAMPING

83-807

The Nature of the Temporal Solutions of Damped Distributed Systems with Classical Normal Modes

D.J. Inman and A.N. Andry, Jr.
State Univ. of New York at Buffalo, Buffalo, NY 14260, J. Appl. Mech., Trans. ASME, 49 (4), pp 867-870 (Dec 1982) 10 refs

Key Words: Continuous parameter method, Critical damping, Overdamping, Underdamping

Conditions are presented under which the time response of certain distributed parameter systems, assumed to possess classical normal modes, is critically damped, overdamped, or underdamped. The conditions are derived from the definiteness of certain combinations of the coefficient operators of the describing equations. These conditions are compared to previous results and their usefulness is illustrated by examples.

83-808

Motion Characteristics of Floating Structures

A. Nishitani and M. Shinozuka
Dept. of Architecture, Waseda Univ., Tokyo, Japan, ASCE J. Engrg. Mech., 108 (EM6), pp 1277-1296 Dec 1982) 23 figs, 4 tables, 8 refs

Key Words: Floating structures, Damping effects, Time domain method

An engineering approach to the time domain analysis which accounts for the effects of damping is developed for the purpose of evaluating the rigid body response motion of a two-dimensional floating body confined in a fixed basin. Three forms of damping coefficients are considered and experiments are performed to determine how well these forms reproduce the experimental results. The optimum values of the damping ratios are also estimated from the experiments and their use for the analysis of large scale floating bodies is suggested.

83-809

Damping and Metals Characterization

G.F. Weissmann
Bell Labs., 600 Mountain Ave., Murray Hill, NJ 07974, J. Test Eval (ASTM), 10 (1), pp 21-24 (Jan 1982) 4 figs, 6 refs

Key Words: Damping coefficients, Internal friction, Metals, Flexural vibration, Torsional vibration

Damping and internal friction have been used extensively in studies concerned with microstructural and macrostructural changes of crystalline materials and with the mechanism causing inelastic deformations. Damping has seldom been used for metals characterization on an engineering level. Some possible reasons are discussed.

83-810

Damping in Turbine Blade Alloys

A. Wolfenden

Res. and Dev. Ctr., Westinghouse Electric Corp., 1310 Beulah Rd., Pittsburgh, PA 15235, J. Test Eval. (ASTM), 10 (1), pp 17-20 (Jan 1982) 4 figs. 4 refs

Key Words: Damping coefficients, Turbine blades, Alloys

Measurements of the damping capacity Q^{-1} of candidate turbine blade alloys for the Wairakei, New Zealand geothermal power station and other future power stations are reported. The techniques used were the piezoelectric ultrasonic composite oscillator technique at 40 or 80 kHz and stress levels 70 kPa to 37 MPa and the vibrating reed technique at 321 Hz and stress levels 32 to 177 MPa.

FATIGUE

(Also see No. 726)

83-811

Improving the Accuracy of Fatigue Analysis

J.M. Steele and T.C.T. Lam

Stress Technology, Inc., Rochester, NY, Mach. Des., 54 (28), pp 123-126 (Dec 9, 1982) 3 figs, 2 tables

Key Words: Fatigue life, Crack propagation

A five-step procedure, based upon local strains concept, for predicting crack initiation in the determination of cumulative fatigue life is presented.

83-812

Improved Methods for Predicting Spectrum Loading Effects, Volume 1. Technical Summary

J.B. Chang, R.M. Hiyama, and M. Szamossi

North American Aircraft Operations, Rockwell International, Los Angeles, CA, Rept. No. NA-81-234-VOL-1, AFWAL-TR-81-3092-VOL-1, 218 pp (Nov 1981)
AD-A118 295

Key Words: Crack propagation, Flight simulation, Flight vehicles

This report presents the technical details of improved methods for predicting the load interaction effects on crack growth under flight spectrum loading developed in a research effort sponsored by the USAF. These include the cycle-by-cycle crack-growth prediction methods used in the detail design stage, the flight-by-flight crack-growth analysis method for individual aircraft tracking usage, and preliminary design trade-off studies.

83-813

Relation of Toughness Test Values to Fatigue Cracking in Bridges

J.W. Baldwin, Jr. and J.A. Cooper

Dept. of Civil Engrg., Missouri Univ., Columbia, MO, Rept. No. 78-2, FHWA/MO-78/2, 124 pp (Aug 1981)
PB82-258765

Key Words: Fatigue life, Steel, Dynamic tests, Experimental test data, Bridges

Tension, Charpy, dynamic tear, C-399, and da/dN tests were conducted on three heats of A36 steel cut from a highway bridge which had been tested to failure in fatigue.

83-814

Effect of Load History on Fatigue Life

J.T. Ryder and K.N. Lauraitis

Lockheed-California Co., Burbank, CA, Rept. No. LR-29586-1, AFWAL-TR-81-4155, 281 pp (Dec 1981)
AD-A118 084

Key Words: Fatigue life, Layered materials

The primary objectives of this program were to investigate the effects of mechanical load history on the response of laminated graphite/epoxy composites and to analyze the results in a manner such that an expanded foundation is laid for formulating cumulative damage concepts.

83-815
The Effect of Tab Geometry on the Fatigue Life of Fibrous Composites
J. Cernosek and D. Sims
Bell Helicopter Textron, Fort Worth, TX, Exptl. Techniques, 6 (6), pp 5-8 (Dec 1982) 4 figs, 1 table, 1 ref

Key Words: Composite structures, Fatigue life

A new tab geometry has been developed which significantly increases the fatigue life of composite materials under tension-tension fatigue loading. The increased fatigue life more closely represents the true fatigue life of the material. It is proposed that the new tab geometry be adopted as an ASTM Standard for tension-tension fatigue tests.

ELASTICITY AND PLASTICITY

(Also see No. 853)

83-816
Theory of Scattering of Elastic Waves from Flat Cracks of Arbitrary Shape
W.M. Visscher
Theoretical Div., Los Alamos Natl. Lab., Los Alamos, NM 87545, Wave Motion, 5 (1), pp 15-32 (Jan 1983) 10 figs, 10 refs

Key Words: Wave diffraction, Elastic waves, Cracked media

A method, based on a boundary-integral representation of the elastic displacement, for calculating crack-opening-displacements on a flat crack of arbitrary shape and for incident elastic waves of arbitrary direction, polarization, and wavelength is developed and illustrated by application to Rayleigh scattering from two families of crack shapes.

83-817
Experimental Investigation of Pulse Propagation in a Rod of Dissipative Materials
V. Humen and J. Vejvoda
College of Mech. and Textile Engrg., 461 17 Liberec, Czechoslovakia, Strojnicky Casopis, 33 (5), pp 575-589 (1982) 9 figs, 8 refs
(In Czech)

Key Words: Rods, Wave propagation, Viscoelastic materials

An experimental method is developed for the prediction of the change in shape of divergent longitudinal strain pulses during the propagation in a rod of viscoelastic material. The feasibility and accuracy of the procedure are demonstrated by physical experiments conducted on PMMA rods.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

83-818
Sound Intensity (Part 1: Theory)
S. Gade
Technical Review (Bruel & Kjaer), No. 3, 39 pp, 15 figs, 1 table, 13 refs (1982)

Key Words: Sound intensity, Signal processing techniques, Digital filters

The theoretical concept of sound intensity (a quantity describing the net flow of acoustic energy) is described, and it is shown how a distinction is made between the active and reactive parts of sound fields. It is also shown how sound intensity can be measured over a wide frequency range by the use of a specially designed probe, consisting of a pair of closely spaced pressure microphones.

83-819
Sound Intensity (Part II. Instrumentation & Applications)
S. Gade
Technical Review, (4), pp 3-32 (1982) 21 figs, 32 refs

Key Words: Sound intensity, Sound measurement, Measuring instruments, Microphone technique

The practical aspects of instrumentation are examined such as requirements to be fulfilled in the design of the intensity probe, and how the phase mismatch between the two microphone channels can be eliminated. The signal to noise ratio achievable in the use of the two microphone technique is considered, and the instrumentation required for this technique discussed. Typical applications of sound intensity in the fields of sound power measurement and source localization are also illustrated.

83-820

Dosimeters, Impulsive Noise and the OSHA Hearing Conservation Amendment

W.R. Kundert

Industrial Resources, Box 315, Harvard, MA 01451, Noise Control Engrg., 19 (3), pp 74-79 (Nov/Dec 1982) 3 figs, 11 refs

Key Words: Noise measurement, Measuring instruments, Standards and codes

OSHA requires that any impulsive component of a noise be included along with the continuous component in determining compliance. The new Hearing Conservation Amendment explicitly states that impulsive noises are to be included. ANSI Standards for both sound level meters and dosimeters do not include tests adequate to ensure reasonable accuracy when impulsive noises are present. Standardization work is underway to add specifications and tests to the ANSI standard for dosimeters, S1.25-1978, that will ensure capability to measure impulsive noise.

83-821

The Effect of Non-Linearity on Transfer Function Measurement

N. Okubo

Chuo Univ., Tokyo, Japan, S/V, Sound Vib., 16 (11), pp 34-37 (Nov 1982) 11 figs, 4 refs

Key Words: Transfer functions, Impact tests, Measurement techniques, Nonlinear response

In modal analysis transfer functions are measured on the basis of linearity – the ratio between the excitation force and the response is assumed to be constant. In most mechanical structures, however, this assumption cannot be satisfied due to nonlinearities. In this article, the time response of mechanical structures with one-degree-of-freedom and nonlinearities are calculated for impact force excitations. The resulting transfer function discrepancies are reviewed.

83-822

Precondensation Phenomena in Acoustic Measurements

J.B. Mehl and M.R. Moldover

National Bureau of Standards, Washington, DC, J. of Chemical Physics, pp 455-465 (July 1982)

Key Words: Acoustic resonators, Acoustic measurement

Theoretical and experimental studies of the behavior of acoustic resonators whose walls are coated with a film of condensed vapor are reported. As a sound wave is reflected from the resonator walls, further condensation and evaporation will alter the thickness of the condensed film during the course of an acoustic cycle. The authors demonstrate that the same inhomogeneous precondensation phenomena can easily be seen in propane at ambient temperature. These precondensation phenomena will influence measurements of acoustic virials at low temperatures, as well as the behavior of certain acoustic thermometers.

83-823

Improved Acceleration-Resistant Crystal Resonator

R.L. Filler

Dept. of Army, Washington, DC, U.S. Patent Appl. No. 6-389 315, 9 pp (June 1982)

Key Words: Resonators

A crystal resonator features two crystals mounted such that the acceleration sensitivity vector of one crystal 5 is in an antiparallel relationship to the acceleration sensitivity vector of the other crystal. The composite resonator eliminates acceleration-induced frequency shifts for acceleration in all directions.

83-824

Thickness Shear, Thickness Twist, and Flexural Vibrations of Rectangular AT-Cut Quartz Plates with Patch Electrodes

P.C.Y. Lee, C. Zee, and C.A. Brebbia

Dept. of Civil Engrg., Princeton Univ., Princeton, NJ 08544, J. Acoust. Soc. Amer., 72 (6), pp 1855-1862 (Dec 1982) 14 figs, 10 refs

Key Words: Plates, Quartz resonators, Flexural vibration

The influence of the size and the mass of patch (rectangular) electrodes on the vibrations and energy trapping in a plated rectangular crystal plate is studied. Mindlin's two-dimensional approximate equations of vibrations of crystal plates are employed for which the coupled modes of thickness shear, thickness twist, and flexure are retained. Numerical solutions that satisfy the free-edge conditions of the plate and the continuity conditions of stresses and displacements at the interface of the plated and unplated regions of plate are obtained by the finite element method using displacement formulation. Numerical computations are made for rectangular AT-cut quartz plates with symmetrically placed, patch electrodes. Resonance frequencies and their corresponding two-dimensional modes of vibrations are obtained for various dimensions of plate and electrodes, and for different masses of electrodes.

83-825
Dynamic Force Transducer – Type TDJ-30
Longgen Zhu, et al
J. of Tung-Chi Univ., (4), pp 112-118 (1981)
CSTA No. 681-81.38

Key Words: Transducers, Measuring instruments

Dynamic force transducer type TDj-30 is designed to measure dynamic forces. It is a small permanent preloaded transducer, having a range of 30 kg tensile to 30 kg compressive. With a load of 5 grams mounted on its top, the resonant frequency is over 8.5 KHz. When connected with a vibration exciter, the transducer can be used to measure and control the applied dynamic forces, and when used together with an accelerometer it can also determine mechanical impedance.

83-826
Design of the Vibration Pick-Up Model GCS-1 for Engineering Survey
Yuren Hu
J. of Tung-Chi Univ., (3), pp 77-88 (1981)
CSTA No. 681-81.36

Key Words: Vibration probes, Displacement measurement

Using the method of transfer function analysis, an intact theoretical basis of vibrating displacement pick-up of pendulum type has been analyzed. The response of the pendulum system is also studied. A new type element of circular-tube shaped spring has been adopted; thus the equipment structure is simplified and the installed elements are reduced.

83-827
Development of a Differential Capacitance Accelerometer
Hongfu Shen, et al
J. of Tung-Chi Univ., (3), pp 89-92 (1981)
CSTA No. 681-81.37

Key Words: Accelerometers, Measuring instruments

The differential capacitance accelerometer has the following advantages: it can be used to measure the acceleration of zero Hz; it can work under extreme circumstances; it is small in size and light in weight; its sensitivity is high and its required follow-up apparatus is simple. All these advantages make it quite a new accelerometer with wide applications which are analyzed and discussed in detail.

83-828
Flutter Compensation of Tape Recorded Signals for Narrow Band Analysis
J.F. Michaelsen and N. Møller
Technical Review, 4, pp 33-41 (1982) 9 figs, 1 ref

Key Words: Tape recorders, Flutter

Fluctuations in tape speed of tape recorders cause distortion of recorded and reproduced signals known as flutter. The effect of flutter is seen as noise in the low frequency range below 100 Hz, and as sideband components located around the main data frequency components due to frequency modulation. This article shows how these components are suppressed using a specially developed plug-in module when the tape recorder Type 7005 is used in conjunction with the High Resolution Signal Analyzer Type 2033. Results obtained using this module are also illustrated.

83-829
Earthquake Motions Using a New Data Processing Scheme
S.S. Sunder and B. Schumacker
Massachusetts Inst. of Tech., Cambridge, MA 02139, ASCE J. Engrg. Mech., 108 (EM6), pp 1313-1329 (Dec 1982) 9 figs, 1 table, 15 refs

Key Words: Earthquakes, Ground motion, Response spectra, Data processing

The significant improvements in the reliability of ground motion and response spectrum estimates that arise from a new procedure for processing strong-motion earthquake signals using state-of-the-art filter design and implementation techniques are illustrated through a series of case studies.

DYNAMIC TESTS

(Also see Nos. 871, 872)

83-830
Vibration Qualification of Electronic Instrumentation for Underground Coal Mining Machinery
R.C. Bartholomae, B.S. Murray, and R. Madden
Pittsburgh Res. Ctr., Bureau of Mines, Pittsburgh, PA, Rept. No. BUMINES-IC-8883, 15 pp (June 1982)
PB82-257544

Key Words: Vibration tests, Testing techniques, Mining equipment

An accurate characterization of the vibration environment and a vibration qualification test derived from it will be a very useful tool for manufacturers of instrumentation for use on underground coal mining equipment. Recognizing this, the Bureau of Mines sponsored a study wherein vibration levels were measured on mining equipment to form a basis for developing the required vibration test.

83-831

Nondestructive Inspection and Evaluation of Composite-Material Flywheels

D.M. Boyd, B.W. Maxfield, S.V. Kulkarni, and A.J. Schwarber

Lawrence Livermore Natl. Lab., CA, Rept. No. UCRL-53264-V.1, 12 pp (Feb 24, 1982)

DE82014875

Key Words: Nondestructive tests, Flywheels, Composite materials

Several composite panels and flywheel designs were evaluated in support of the Mechanical Energy Storage Technology project. Conventional nondestructive evaluation technology was used on the panels and flywheels. All flywheels and panels were radiographed and, where practical, were also inspected using ultrasonic techniques. The results provided information about the structural features of flywheels and materials. This information is useful for the quality control of fabrication procedures.

83-832

Computer Aided Testing Solves Automotive Vibration Problem

L. Enochson and D. Galyardt

Time Series Associates, Spokane, WA, S/V, Sound Vib., 16 (11), pp 20-31 (Nov 1982) 18 figs, 2 tables

Key Words: Automobiles, Vibration tests, Computer-aided techniques

Excessive steering wheel shake at three operating speeds was observed in a modified BMW 320i. Computer aided testing techniques were utilized to identify the source of the vibration and to simulate structural modifications which would alleviate the problem.

DIAGNOSTICS

(Also see No. 864)

83-833

The Diagnosis of the Components of Turbo-jet Engines by Means of Gas Dynamic Parameter Monitoring (Zur Diagnose von Komponentenstörungen in Turboluftstrahlantrieben mit gasdynamischer Parameterüberwachung)

A. Spirkl

Fortschritt-Berichte VDI-Zt., Series 7, No. 67, 170 pp, 39 figs, 18 tables. Summarized in VDI-Z., 124 (18), pp 707-708 (Sept 1982), 1 fig. Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Dusseldort 1, Germany. Price 96.-DM

(In German)

Key Words: Diagnostic techniques, Jet engines

The essential tasks in power plant monitoring are the detection of an abnormal condition, and then diagnosis and prognosis of machinery health. This report deals with prognosis; i.e., the prediction, by means of trending, when a failure, or a maximum permissible deterioration of a component, is to be expected. The prognostic parameters of components cannot be measured directly; they are determined indirectly from the measured physical values of power plants. The models describing the relationship between the parameters of components and the power plant values are discussed. Since the number of measurable values is limited, only certain potential disturbances can be predicted. Therefore, a technique was developed which takes into account the unmeasurable values as well as the error functions of the instruments and the expected accuracy of the measurement. The error-proof diagnostic technique for the diagnosis of thermodynamic condition of power plant components is intended for use with digital computers and can be used on ground and in flight.

83-834

Aerothermal-Mechanical Health Monitoring and Diagnostics of Turbo-Compressor Sets

M.P. Boyce and C. Meher-Homji

Boyce Engineering International, Inc., Houston, TX, Turbomachinery Symposium, Proc. of the 11th, Texas A&M Univ., College Station, TX, Dec 14-16, 1982, pp 75-94, 23 figs, 12 tables

Key Words: Monitoring techniques, Diagnostic techniques, Turbomachinery

The petrochemical industry has in the past placed a heavy emphasis on mechanical (vibration) analysis for both health monitoring and diagnostics. This paper presents a methodology in which both mechanical and aerothermal parameters are utilized for machinery health monitoring, prognosis and diagnosis.

BALANCING

83-835

Dynamic Balancing with Micro Processors

D.G. Stadelbauer

Schenck Trebel Corp., Deer Park, NY 11729, Shock Vib. Dig., 14 (12), pp 3-7 (Dec 1982) 6 figs

Key Words: Balancing techniques, Dynamic balancing, Microprocessors (computers), Reviews

This article describes the use of micro processors in balancing.

MONITORING

(Also see No. 834)

83-836

Vibration and Balance Problems in Fossil Plants: Industry Case Histories

A.F. Armor

Elec. Power Res. Inst., 3412 Hillview Ave., Palo Alto, CA 94304, Rept. No. EPRI CS-2725, 168 pp (Nov 1982)

Key Words: Monitoring techniques, Fossil power plants, Case histories

Actual field case histories – including those of turbines, generators, fans, pumps, and electric motors – are presented to demonstrate some practical uses of vibration analysis. Each case history is divided into six sections: definition of the problem, symptoms of the problem, test data and observations, corrective actions taken, final results, and conclusions and recommendations.

83-837

Continuous Monitoring Systems for High Speed Gearing

J.S. Mitchell

John S. Mitchell, Inc., San Juan Capistrano, CA, Turbomachinery Symposium, Proc. of the 11th, Texas A&M Univ., College Station, TX, Dec 14-16, 1982, pp 157-163, 7 figs, 10 refs

Key Words: Monitoring techniques, Gears

This paper describes the dynamics of high speed gears that apply to and influence health monitoring. Various types of monitoring systems that have been proposed and utilized are discussed, followed by the advantages and limitations of each system. Actual case histories are cited to illustrate many of the elements of gear health monitoring. The paper concludes with recommended health monitoring systems for several classes of gears. Each system is described in detail along with the reasons for selecting the specific method.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see Nos. 739, 741)

83-838

Wavefront Analysis in the Nonseparable Elastodynamic Quarter-Plane Problems, 1. Part 1: The General Method

J. Miklowitz

Div. of Engrg. and Appl. Science, California Inst. of Tech., Pasadena, CA 91125, J. Appl. Mech., Trans. ASME, 49 (4), pp 797-807 (Dec 1982) 6 figs, 12 refs

Key Words: Wave propagation

This work concerns the transient response in elastodynamic quarter-plane problems. In particular, the work focuses on the nonseparable problems, developing and using a new method to solve basic quarter-plane cases involving nonmixed edge conditions. Of initial interest is the classical case in which a uniform step pressure is applied to one edge, along with zero shear stress, while the other edge is traction free. The new method of solution is related to earlier work on nonseparable waveguide (semi-infinite layer) problems in which long time, low-frequency response was the objective.

83-839

Wavefront Analysis in the Nonseparable Elastodynamic Quarter-Plane Problems, 1. Part 2: Wavefront Events in the Edge Uniform Pressure Problem

J. Miklowitz

California Inst. of Tech., Pasadena, CA 91125, J. Appl. Mech., Trans. ASME, 49 (4), pp 808-815 (Dec 1982)

Key Words: Wave propagation

All of the quarter-plane wavefront events in the edge uniform pressure problem are derived through further steps in the Cagniard-deHoop inversion and a related asymptotic method due to Rosenfeld and Miklowitz. In the interior of the quarter plane the events include, for the displacements, velocities, and accelerations, the regular dilatational wavefronts, the two-sided equivoluminal and head wavefronts in the two critical regions associated with the edges (surfaces) $x = 0$ and $y = 0$, and the plane dilatational wavefront from the edge input.

83-840

Properties and Extensions of a Single-Step Algorithm for Dynamic Problems

R.M. Thomas

Dept. of Computer Studies, Univ. of Leeds, Leeds LS2 9JT, UK, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (6), pp 871-880 (Nov/Dec 1982) 2 figs, 2 tables, 8 refs

Key Words: Differential equations, Linear systems, Stability, Phase data, Damping coefficients

Recently a new class of single-step methods for solving linear systems of second order ordinary differential equations was introduced. The stability, phase and damping properties of these methods is derived and some possible improvements are suggested with the aim of improving accuracy.

83-841

Stationary and Nonstationary Behavior of Linear Time-Variant and Time Invariant Vibration Systems (Das Stationare und instationare Verhalten linearer, zeitvarianter und zeitinvarianter Schwingungssysteme)

J. Somer and G. Dittrich

Institut f. Getriebetechnik und Maschinendynamik, Rheinisch-Westfalische Technische Hochschule, Aachen, Germany, Fortschritt-Berichte VDI-Zt., Series 11, No. 45, 42 pp (1981). Summarized in VDI-Z, 123 (23/24), p 993 (Dec 1981), Avail: VID-Verlag GmbH, Postfach 1139, 4000 Dusseldorf 1, Germany (In German)

Key Words: Differential equations, Linear theories, Vibration analysis

The mathematical description of stationary and nonstationary linear vibrations is achieved by means of a system of linear inhomogenous differential equations of the most general form. Starting with the solution of homogenous condition equation, using the method of variations of constants, a homogenous equation is obtained. For a system with constant coefficients a direct method for the determination of fundamental matrix by means of Cayley-Hamilton theorem is derived. For a system with variable coefficients the numeric calculation of fundamental matrix is performed by the solution of a nonlinearly constructed differential equation. Thus, a numerical integration of condition equation is performed showing that the trapezoidal rule is fully sufficient for the evaluation of vibrations. The application of the method in an actual case shows the many possibilities for substitution and the capabilities of this technique.

83-842

Linear/Nonlinear Behavior in Unsteady Transonic Aerodynamics

E.H. Dowell, S.R. Bland, and M.H. Williams

Princeton Univ., Princeton, NJ, AIAA J., 21 (1), pp 38-46 (Jan 1983) 15 figs, 17 refs

Key Words: Aerodynamic loads, Linear theories

The accurate calculation of the aerodynamic forces in unsteady transonic flow requires the solution of the nonlinear flow equations. This paper assesses the range of parameters over which linear behavior occurs. In particular, calculations are made for an NACA 64A006 and also an MBB-A3 airfoil oscillating in pitch over a range of amplitudes, frequencies, and Mach numbers. The primary aerodynamic method used is the well known LTRAN2 code of Ballhaus and Goorjian that provides a finite difference solution to the low frequency, small disturbance, two-dimensional potential flow equation. Comparisons are made with linear subsonic theory, local linearization theory, and, for steady flow, with the full potential equation code of Bauer, Garabedian, and Korn in both its conservative and nonconservative form.

83-843

Stabilization under Forced Impulse Constraints (Stabilisierung von Bindungen über Zwangsimpulse)

J. Baumgarte

Mechanik-Zentrum, Techn. Univ., Braunschweig, D-3300 Braunschweig, German Dem. Rep., Z. angew. Math. Mech., 62 (9), pp 447-454 (1982) 6 refs
(In German)

Key Words: Constrained structures

This paper deals with the forces resulting from velocity depending constraints in mechanical systems. These forces described by Gauss's principle of least curvature are transformed in two parts: the momenta of constraints and remaining forces of constraint.

83-844

Dynamic Analysis by Direct Superposition of Ritz Vectors

E.L. Wilson, Ming-Wu Yuan, and J.M. Dickens

Univ. of California, Berkeley, CA, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (6), pp 813-821 (Nov/Dec 1982) 3 figs, 7 tables, 5 refs

Key Words: Ritz method, Dynamic structural analysis

The solution of the eigenvalue problem for large structures is often the most costly phase of a dynamic response analysis. In this paper the need for the exact solution of this large eigenvalue problem is eliminated. A new algorithm, based on error minimization, is presented for the generation of a sequence of Ritz vectors. These orthogonal vectors are used to reduce the size of the system. Only Ritz vectors with a large participation factor are used in the subsequent mode superposition analysis. The proposed method not only reduces computer time requirements significantly but provides an error estimation for the dynamic analysis.

83-845

An FFT Algorithm for Structural Dynamics

J.F. Hall

Dept. of Civil Engrg., California Inst. of Tech., Pasadena, CA, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (6), pp 797-811 (Nov/Dec 1982) 5 figs, 5 tables, 6 refs

Key Words: Fast Fourier transform, Dynamic structural analysis

A Fast Fourier Transform algorithm (FFT) is described which is especially suited for structural dynamics. The routine incorporates several features selected from many variations of the original Cooley and Tukey algorithm with the goal of making the most efficient use of computer time and storage while maintaining simplicity. Some introductory material to Fourier transform techniques and a description of the original algorithm are also included. In addition, the source listing of the subroutine FFT is reproduced.

83-846

A Re-Evaluation of Equivalent Linear Models for Simple Yielding Systems

A.H. Hadjian

Bechtel Power Corp., Norwalk, CA, Intl. J. Earthquake Engrg. Struc. Dynam., 10 (6), pp 759-767 (Nov/Dec 1982) 5 figs, 1 table, 9 refs

Key Words: Linear systems, Harmonic excitation, Seismic excitation

Commonly used equivalent linear models for simple yielding systems subjected to harmonic and earthquake excitations are reevaluated.

83-847

Analytical Frequency-Response Functions for a Structural System

R. Rodeman, C.F. Briner, and M.J. Sagartz

Sandia Natl. Labs., Albuquerque, NM, Rept. No. SAND-82-0256C, CONF-820614-1, 3 pp (1982) DE82011028

Key Words: Frequency response functions, Shells, Cylindrical shells, Random response

The problem of determining the random response of a structural system requires a knowledge of the appropriate frequency response functions over the frequency range of interest. If the excitation is broadband and the structure is lightly damped, conventional finite element methods of obtaining the frequency response functions are both time consuming and costly. A technique is presented here where frequency response functions for reasonably complex structures can be found in an expensive and timely manner. Once these functions are obtained, the response to an arbitrary stationary random or transient excitation with the specified spatial distribution may be found.

83-848

On the "Best" Mode Form in the Mode Approximation Technique Using the Finite Element Method

S. Slutsky, C.T. Chon, and K.S. Yeung

Harvard Univ., Cambridge, MA, J. Struc. Mech., 10 (1), pp 117-131 (1982) 7 figs, 1 table, 13 refs

Key Words: Finite element technique, Mode shapes

A systematic procedure for choosing the best mode shape is discussed by extending the mode approximation technique. The finite element method is used to calculate several valid mode forms of a given structure. Nonlinear eigenvalue problems are solved by an iterative procedure in order to obtain mode forms. Since one can choose only one mode form in the mode approximation technique due to nonlinearity of viscoplastic materials, the lower bound theorem on final time is applied to identify the best mode form. The validity of the concept is demonstrated by numerical results from two example problems of clamped beam and portal frame.

83-849

A Theory of Substructure Modal Synthesis

K. Kubomura

Rockwell International, Space Transportation Systems, 12214 Lakewood Blvd., Downey, CA 90241, J. Appl. Mech., Trans. ASME, 49 (4), pp 903-909 (Dec 1982) 2 tables, 14 refs

Key Words: Modal synthesis, Substructuring methods, Finite element technique

A theory is presented for representing the displacements of a substructure finite-element mathematical model with a reduced number of degrees of freedom. A first or second-order approximation is used for the substructure's modal coordinates associated with significantly larger or smaller eigenvalues than the system eigenvalues of excitation. The derived representations of the substructure displacements are capable of employing any type of substructure natural mode; free-free, cantilever or hybrid mode, and of retaining the dynamic behavior of any frequency range.

83-850

A Probabilistic Theory of Nonlinear Dynamical Systems Based on the Cell State Space Concept

C.S. Hsu

Univ. of California, Berkeley, CA 94720, J. Appl. Mech., Trans. ASME, 49 (4), pp 895-902 (Dec 1982) 1 fig, 8 refs

Key Words: Dynamic systems, Probability theory

A probabilistic theory is developed for nonlinear dynamical systems. The theory is based on discretizing the state space into a cell structure and using the cell probability functions to describe the state of a system. Although the dynamical system may be highly nonlinear the probabilistic formulation always leads to a set of linear ordinary differential equations. The evolution of the probability distribution among the cells can then be studied by applying the theory of Markov processes to this set of equations. It is believed that this development possibly offers a new approach to the global analysis of nonlinear systems.

83-851

Compact Probabilistic Representation of Random Processes

S.F. Masri and R.K. Miller

Civil Engrg. Dept., Univ. of Southern California, Los Angeles, CA 90007, J. Appl. Mech., Trans. ASME, 49 (4), pp 871-876 (Dec 1982) 7 figs, 5 refs

Key Words: Random vibration, Probability theory

A method is given for representing analytically defined or data-based covariance kernels of arbitrary random processes in a compact form that results in simplified, analytical, random-vibration transmission studies. The method uses two-dimensional orthogonal functions to represent the covariance kernel of the underlying random process. Such a representation leads to a relatively simple analytical expression for the covariance kernel of the linear system response which consists of two independent groups of terms: one reflecting the input characteristics, and the other accounting for the transmission properties of the excited dynamic system. The utility of the method is demonstrated by application to a covariance kernel widely used in random-vibration studies.

83-852

A Variable Parameter Incrementation Method for Dynamic Instability of Linear and Nonlinear Elastic Systems

S.L. Lau, Y.K. Cheung, and S.Y. Wu

Dept. of Civil Engrg., Univ. of Hong Kong, Hong Kong, J. Appl. Mech., Trans. ASME, 49 (4), pp 849-853 (Dec 1982) 5 figs, 9 refs

Key Words: Beams, Columns, Incremental methods, Parametric response

A variable parameter incrementation method is proposed and then applied to the determination of parametric instability boundary of columns. Attention is particularly paid to the geometrically nonlinear problems including the instability of nonlinear vibrations. Although only beam and column problems are treated at present, the approach is believed to be general in methodology. This method is not subjected to the limitations of small exciting parameters and weak nonlinearity.

83-853

A Global Local Finite Element Analysis of Axisymmetric Scattering of Elastic Waves

D.B. Goetschel, S.B. Dong, and R. Muki

Aeronautical Engrg. and Mechanics, Rensselaer Polytechnic Inst., Troy, NY 12181, J. Appl. Mech., Trans. ASME, 49 (4), pp 816-820 (Dec 1982) 4 figs, 18 refs

Key Words: Elastic waves, Finite element technique, Wave scattering

A global local finite element method is developed for axisymmetric scattering of a steady, compressive, incident elastic wave in a homogeneous, isotropic host medium by an axisymmetric inclusion. The inclusion may be arbitrary with respect to its geometry and can have inhomogeneous, anisotropic elastic material properties. Examples on spheroidal and finite circular cylindrical inclusions are given.

83-854

Bounds on the Probability of Failure in Random Vibration

P. Thoft-Christensen and S.R.K. Nielsen

Aalborg University Centre, DK-9100 Aalborg, Denmark, J. Struc. Mech., 10 (1), pp 67-91 (1982) 7 figs, 4 tables, 18 refs

Key Words: Failure analysis, Random excitation, Probability theory

A new method to construct upper and lower bounds for the failure probability of a structure exposed to random excitations is presented. The method is based on an extension of the classical inclusion-exclusion series of Rice where the main idea is to take into consideration only realizations which are in the safe area at a number of previous instants of time. By a numerical example it is demonstrated that this method may lead to rather sharp bounds.

83-855

Survival Probability of Non-Linear Oscillators Subjected to Broad-Band Random Disturbances

P.-T.D. Spanos

Dept. of Engrg. Mechanics, Univ. of Texas, Austin, TX 78712, Intl. J. Nonlin. Mech., 17 (5/6), pp 303-317 (1982) 9 figs, 21 refs

Key Words: Oscillators, Damped structures, Random excitation

An analytical method is developed for examining the first-passage problem formulated in context with the response of a class of lightly damped nonlinear oscillators to broad-band random excitations. A circular (E-type) barrier is considered. The amplitude of the oscillator response is modeled as a Markovian process. This modeling leads to a backward Kolmogorov equation which governs the evolution of the survival probability of the oscillator.

83-856

Application of Matrix Method for Dynamical Analysis of Thin-Walled Prismatic Elements of the Closed Cross-Section

F. Šimčák

Dept. of Mech. Engrg. of the Tech. Univ. Košice, Czechoslovakia, Strojnicky Casopis, 33 (5), pp 529-542 (1982) 4 figs, 8 refs
(In Slovak)

Key Words: Matrix methods, Prismatic bodies

The contribution deals with the matrix method for determination of self oscillation of thin-walled prismatic elements closed, unbranched cross-section consisting of direct sections. Differential equations of self oscillations are derived considering the constant prestress neglecting secondary shear deformations and rotary inertia, and the possibility of their solution is shown. The application of the method is illustrated by an example.

NONLINEAR ANALYSIS

(See No. 857)

NUMERICAL METHODS

83-857

Implicit Numerical Integration for Periodic Solutions of Autonomous Nonlinear Systems

G.A. Thurston
NASA Langley Res. Ctr., Hampton, VA 23655, J. Appl. Mech., Trans. ASME, 49 (4), pp 861-866 (Dec 1982) 3 figs, 8 refs

Key Words: Numerical analysis, Nonlinear systems

A change of variables that stabilizes numerical computations for periodic solutions of autonomous systems is derived. Computation of the period is decoupled from the rest of the problem for conservative systems of any order and for any second-order system. Numerical results are included for a second-order conservative system under a suddenly applied constant load. Near the critical load for the system, a small increment in load amplitude results in a large increase in amplitude of the response.

83-858

A Numerical Method for Distributed Parameter Structural Optimization Problems with Repeated Eigenvalues

K.K. Choi, E.J. Haug, and H.L. Lam
College of Engrg., Univ. of Iowa, Iowa City, IA, J. Struc. Mech., 10 (2), pp 191-207 (1982) 4 tables, 12 refs

Key Words: Eigenvalue problems, Continuous parameter method, Numerical analysis

A numerical method for solving distributed parameter structural optimization problems in which repeated eigenvalues may occur is formulated. Recent results on directional differentiability of repeated eigenvalues are used to develop a generalized steepest descent method for structural optimization. The algorithm is shown to overcome technical difficulties associated with nondifferentiability of repeated eigenvalues. The method is used to optimize design of a clamped-clamped column in which a repeated eigenvalue occurs.

83-859

Nonlinear Aerodynamic Modeling of Flap Oscillations in Transonic Flow: A Numerical Validation

W.J. Chyu and L.B. Schiff
NASA Ames Res. Ctr., Moffett Field, CA, AIAA J., 21 (1), pp 106-113 (Jan 1983) 9 figs, 16 refs

Key Words: Aircraft, Aerodynamic loads, Numerical analysis

The regime of validity of a nonlinear aerodynamic force and moment formulation, based on concepts from nonlinear functional analysis and applicable to a transonic airfoil with a deflecting flap, is investigated. A time-dependent finite difference technique is used to evaluate the aerodynamic data of the formulation in terms of specified, characteristic motions.

83-860

Status of Numerical Analysis in Automotive Engineering (Stand der Berechnung im Automobilbau)

D. Radaj
Automobiltech Z., 84 (11), pp 535-539 (Nov 1982) 9 figs, 23 refs
(In German)

Key Words: Automobiles, Collision research (automotive), Proceedings

Numerical analysis techniques applicable to various topics of automotive engineering, which were discussed at a recent conference, are presented. Among them are driving and structural dynamics, passenger compartment acoustics, vehicle aerodynamics, vehicle thermodynamics, crash behavior, engine mechanics, engine fluid mechanics, engine thermodynamics, power train and chassis design as well as car body analysis.

83-861

Numerical Evaluation of the Rayleigh Integral for Planar Radiators Using the FFT

E.G. Williams and J.D. Maynard
Dept. of Physics, Pennsylvania State Univ., University Park, PA 16802, J. Acoust. Soc. Amer., 72 (6), pp 2020-2030 (Dec 1982) 12 figs, 28 refs

Key Words: Numerical analysis, Wave propagation, Near-field region, Fast Fourier transform, Error analysis

Rayleigh's integral formula is evaluated numerically for planar radiators of any shape, with any specified velocity in the source plane using the fast Fourier transform algorithm. The major advantage of this technique is its speed of computation – over 400 times faster than a straightforward two-dimensional numerical integration. The technique is developed for computation of the radiated pressure in the nearfield of the source and can be easily extended to provide, with little computation time, the vector intensity in the nearfield. Computations with the FFT of the nearfield pressure of baffled rectangular plates with clamped and free boundaries are compared with the exact solution to illuminate any errors. The bias errors, introduced by the FFT, are investigated and a technique is developed to significantly reduce them.

STATISTICAL METHODS

(Also see No. 764)

83-862

Stochastic SH Waves Along a Frictional Interface

R.K. Miller
Univ. of Southern California, Los Angeles, CA 90007, ASCE J. Engrg. Mech., 108 (EM6), pp 1262-1276 (Dec 1982) 5 figs, 9 refs

Key Words: Wave absorption, Wave reflection, Wave refraction, Stochastic processes

The reflection, refraction, and absorption of a planar SH wave with stochastic time dependence at a frictionally bonded interface between elastic solids is considered. Exact and approximate solutions are presented for the probability density functions of the transmitted and reflected stress waves and for the rate of slip at the interface. Results are also presented for the stationary and nonstationary mean-square values of these quantities, the mean energy flux partitioning between the various waves, and the mean rate of energy dissipation at the interface.

PARAMETER IDENTIFICATION

83-863

Identification of Linear Structural Dynamic Systems

M. Shinozuka, Chung Bang Yun, and H. Imai
Columbia Univ., New York, NY 10027, ASCE J. Engrg. Mech., 108 (EM6), pp 1371-1389 (Dec 1982) 5 figs, 3 tables, 20 refs

Key Words: System identification techniques, Multidegree of freedom systems, ARMA (auto-regressive/moving-average) models

This paper studies methods of parameter estimation for linear multi-degree-of-freedom structural dynamic systems, based on observed records of the external forces and the structural responses. The auto-regressive and moving-average (ARMA) model is used for this purpose. It is found that the ARMA model is a convenient model representing linear multi-degree-of-freedom structural dynamic systems and that the model is higly compatible with the instrumental variable method and the maximum likelihood method of identification.

83-864

Modeling and Identification of Nonlinear Dynamic Systems

H.A. Sassi
Ph.D. Thesis, Univ. of Southern California (1982)

Key Words: System identification techniques, Diagnostic techniques

A method is presented for the identification of dynamic systems with arbitrary nonlinearities including those of a hysteretic nature. The method uses information about the system state variables (displacement and velocity) and matches its response by using appropriate orthogonal functions (Chebyshev polynomials). The technique is used to identify multidegree-of-freedom systems and is applied to several examples in structural dynamics.

OPTIMIZATION TECHNIQUES

83-865

Optimization of Structures under Shock and Vibration Environment

S.S. Rao
Dept. of Mech. Engrg., San Diego State Univ., San Diego, CA 92182, Shock Vib. Dig., 14 (12), pp 9-15 (Dec 1982) 60 refs

Key Words: Optimization, Shock response, Vibration response, Reviews

A general structural optimization problem is defined. A classification of structural optimization applications is based on the nature of the major behavior constraint. Recent work in each class of problems is reviewed. Developments in the area of optimization methods and sensitivity analysis are discussed. Structural optimization problems that need further investigation are summarized.

COMPUTER PROGRAMS

83-866

Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA: Program Maintenance Manual

P. Zimmerman and J. Higgins
Federal Highway Admn., Arlington, VA, Rept. No. FHWA-DP-58-2, FHWA/DF-82/001B, 177 pp (June 1982)
PB82-218736

Key Words: Computer programs, Noise barriers, Design techniques

The barrier cost reduction procedure is composed of two computer programs: STAMINA 2.0, the FHWA highway traffic noise prediction model; and OPTIMA, an interactive program which helps the user design cost-efficient noise barrier designs. This manual describes the programs, and their subroutines in detail.

83-867

Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA: User's Manual

W. Bowlby, J. Higgins, and J. Reagan

Federal Highway Admn., Arlington, VA, Rept. No. FHWA-DP-58-1, FHWA/DF-82/001A, 202 pp (Apr 1982)

PB82-218744

Key Words: Computer programs, Noise barriers, Design techniques

This manual presents the operation of the barrier cost reduction procedure. The FHWA Level 2 noise prediction model (STAMINA 1.0) has been modified to calculate the sound energy passing over several barrier segment heights in one run. The information is then used in an interactive program (OPTIMA) which can guide the user to the most efficient noise barrier design. The user is shown, step-by-step, how to input information and to interpret the output results for both STAMINA and OPTIMA.

83-868

FAUN: A Program for the Analysis of Frameworks, Pipeworks and Shells Using the UNCLE Finite Element Scheme

J.A. Knowles

Nuclear Power Dev. Establishment, UKAEA, Risley, UK, Rept. No. ND-R-569(R), 109 pp (June 1981)

DE82701341

Key Words: Computer programs, Frames, Shells, Pipes (tubes), Finite element technique

FAUN is a general purpose program for the elastic analysis of frameworks, pipeworks and shells. It can be used for both static and dynamic analysis. The structure is subdivided into a number of elements and the mesh analyzed using the geometry of the system, the properties of the components and the loading and restraint conditions. A wide variety of elements is available to describe beam, pipe, plate, shell and membrane structures.

83-869

Finite-Difference Solution of the Compressible Stability Eigenvalue Problem

M.R. Malik

Systems and Applied Sciences Corp., Hampton, VA, Rept. No. NASA-CR-3584, 50 pp (June 1982)

N82-28573

Key Words: Computer programs, Eigenvalue problems, Finite difference method

A compressible stability analysis computer code is developed. The code uses a matrix finite difference method for local eigenvalue solution when a good guess for the eigenvalue is available and is significantly more computationally efficient than the commonly used initial value approach.

GENERAL TOPICS

CONFERENCE PROCEEDINGS

83-870

Computational Methods in Ground Transportation Vehicles

Winter Annual Meeting of ASME, Phoenix, AZ, Nov 14-19, 1982, ASME-AMD-Vol. 50. M.M. Kamal and J.A. Wolf, Jr., eds., ASME, 1982, 222 pp

Key Words: Ground vehicles, Transportation vehicles, Suspension systems (vehicles), Design techniques, Dynamic structural analysis, Computer-aided techniques, Proceedings

The purpose of this symposium is to bring together a sampling of the computational methods in use today in ground transportation vehicle design and to attempt to point out new problem areas and needs. It is hoped that this expose will stimulate the interest of theoretical and applied mechanicists to advance the development of new computational methods for solving problems still beyond the current state of the art.

CRITERIA, STANDARDS, AND SPECIFICATIONS

(See No. 820)

BIBLIOGRAPHIES

83-871

Nondestructive Testing of Ceramics. 1972 - September 1982 (Citations from the International Aerospace Abstracts Data Base)

NTIS Rept. for 1972 - Sept 1982, 88 pp (Sept 1982)
PB82-874082

Key Words: Bibliographies, Nondestructive tests, Testing techniques, Ceramics

This bibliography contains 78 citations concerning the nondestructive techniques for testing or examining ceramic materials and ceramic bodies for the detection of flaws or defects.

83-872

Nondestructive Testing of Composite Materials. 1972 - September, 1982 (Citations from the International Aerospace Abstracts Data Base)

NTIS Rept. for 1972 - Sept 1982, 172 pp (Sept 1982)
PB82-874009

This bibliography contains 159 citations concerning the nondestructive techniques for testing or examining a wide variety of composite materials. To. , discussed are the detection of flaws or defects which affect the mechanical properties and behavior of composite materials.

USEFUL APPLICATIONS

83-873

Acoustical Spectroscopy of Violins

E.B. Arnold and G. Weinreich
Randall Lab. of Physics, Univ. of Michigan, Ann Arbor, MI 48109, J. Acoust. Soc. Amer., 72 (6), pp 1739-1746 (Dec 1982) 9 figs, 12 refs

Key Words: Normal modes, Violins

The normal modes of the violin system are investigated by studying its response to external excitation by an incident sinusoidal sound wave of variable frequency. Appropriate transducers are used to sense the vibration of wood, air, and strings. The data are analyzed by computer to yield information on the complex eigenfrequencies and eigenfunctions of the various normal modes. Methods of minimizing errors due to resonances outside the frequency window are discussed. Some representative results are shown.

AUTHOR INDEX

TECHNICAL NOTES

R.B. Bhat
Vibrations of Panels with Non-Uniformly Spaced Stiffeners
J. Sound Vib., 84 (3), pp 449-452 (Oct 8, 1982)
2 figs, 5 refs

K.B. Rasmussen
A Note on the Calculation of Sound Propagation over Impedance Jumps and Screens
J. Sound Vib., 84 (4), pp 598-602 (Oct 22, 1982)
3 figs, 6 refs

J.R. Kuttler and V.G. Sigillito
Frequencies of Limacons and Cardioids that have Applications to Waveguides and Mitral Valves
J. Sound Vib., 84 (4), pp 603-605 (Oct 22, 1982)
1 table, 14 refs

B. Hay
Assessment of Noise Nuisance in the UK Compared with Germany, France, Denmark and Australia (as at 1982)
Appl. Acoust., 15 (6), pp 459-468 (Nov 1982) 3 tables, 25 refs

A.S. Atadan and K. Huseyin
A Note on "A Uniformly Valid Asymptotic Solution for $d^2y/dt^2 + y = a + \epsilon y^2$"
J. Sound Vib., 85 (1), pp 129-131 (Nov 8, 1982)
7 refs

G.R. Torr and D.R. Jarvis
A Method, Amenable to Computer Control, for the Determination of U/i in the Reciprocity Calibration of Condenser Microphones
J. Sound Vib., 85 (1), pp 132-135 (Nov 8, 1982)
1 fig, 5 refs

A. Krishnan and M. Sithu
Influence of Rotary Inertia on the Fundamental Frequency of a Cantilever Beam
J. Sound Vib., 85 (1), pp 136-140 (Nov 8, 1982)
3 tables, 5 refs

P.N. Singh
A New Technique of Partially Integrating Some Non-Linear Vibration Equations
J. Sound Vib., 85 (1), pp 141-142 (Nov 8, 1982)
2 refs

E.R. Johnson
Load-Frequency Relations for a Clamped Shallow Circular Arch
AIAA J., 20 (12), pp 1763-1764 (Dec 1982)

CALENDAR

MAY 1983

9-13 Acoustical Society of America, Spring Meeting [ASA] Cincinnati, OH *(ASA Hqs.)*

9-13 Symposium on Interaction of Non-Nuclear Munitions with Structures [U.S. Air Force] Colorado Springs, CO *(Dr. C.A. Ross, P.O. Box 1918, Eglin AFB, FL 32542 - (904) 822-5614)*

17-19 Fifth Metal Matrix Composites Technology Conference [Office of the Undersecretary of Defense for Research and Engineering] Naval Surface Weapons Center, Silver Spring, MD *(MMCIAC - Kaman Tempo, P.O. Drawer QQ, Santa Barbara, CA 93102 - (805) 963-6455/6497)*

JUNE 1983

6-10 Passenger Car Meeting [SAE] Dearborn, MI *(SAE Hqs.)*

20-22 Applied Mechanics, Bioengineering & Fluids Engineering Conference [ASME] Houston, TX *(ASME Hqs.)*

JULY 1983

11-13 13th Intersociety Conference on Environmental Systems [SAE] San Francisco, CA *(SAE Hqs.)*

AUGUST 1983

8-11 Computer Engineering Conferences and Exhibit [ASME] Chicago, IL *(ASME Hqs.)*

8-11 West Coast International Meeting [SAE] Vancouver, B.C. *(SAE Hqs.)*

SEPTEMBER 1983

11-13 Petroleum Workshop and Conference [ASME] Tulsa, OK *(ASME Hqs.)*

11-14 Design Engineering Technical Conference [ASME] Dearborn, MI *(ASME Hqs.)*

12-15 International Off-Highway Meeting & Exposition [SAE] Milwaukee, WI *(SAE Hqs.)*

14-16 International Symposium on Structural Crashworthiness [University of Liverpool] Liverpool, UK *(Prof. Norman Jones, Dept. of Mech. Engrg., The Univ. of Liverpool, P.O. Box 147, Liverpool L69 3BX, England)*

25-29 Power Generation Conference [ASME] Indianapolis, IN *(ASME Hqs.)*

OCTOBER 1983

17-19 Stapp Car Crash Conference [SAE] San Diego, CA *(SAE Hqs.)*

17-20 Lubrication Conference [ASME] Hartford, CT *(ASME Hqs.)*

18-20 54th Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, DC] Pasadena, CA *(Mr. Henry C. Pusey, Director, SVIC, Naval Research Lab., Code 5804, Washington, DC 20375)*

NOVEMBER 1983

6-10 Truck Meeting and Exposition [SAE] Cleveland, OH *(SAE Hqs.)*

7-11 Acoustical Society of America, Fall Meeting [ASA] San Diego, CA *(ASA Hqs.)*

13-18 American Society of Mechanical Engineers, Winter Annual Meeting [ASME] Boston, MA *(ASME Hqs.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS:	American Federation of Information Processing Societies 210 Summit Ave., Montvale, NJ 07645
AGMA:	American Gear Manufacturers Association 1330 Mass Ave., N.W. Washington, D.C.
AHS:	American Helicopter Society 1325 18 St. N.W. Washington, D.C. 20036
AIAA:	American Institute of Aeronautics and Astronautics, 1290 Sixth Ave. New York, NY 10019
AIChE:	American Institute of Chemical Engineers 345 E. 47th St. New York, NY 10017
AREA:	American Railway Engineering Association 59 E. Van Buren St. Chicago, IL 60605
ARPA:	Advanced Research Projects Agency
ASA:	Acoustical Society of America 335 E. 45th St. New York, NY 10017
ASCE:	American Society of Civil Engineers 345 E. 45th St. New York, NY 10017
ASME:	American Society of Mechanical Engineers 345 E. 45th St. New York, NY 10017
ASNT:	American Society for Nondestructive Testing 914 Chicago Ave. Evanston, IL 60202
ASQC:	American Society for Quality Control 161 W. Wisconsin Ave. Milwaukee, WI 53203
ASTM:	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103
CCCAM:	Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada
ICF:	International Congress on Fracture Tohoku Univ. Sendai, Japan
IEEE:	Institute of Electrical and Electronics Engineers 345 E. 47th St. New York, NY 10017
IES:	Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056
IFToMM:	International Federation for Theory of Machines and Mechanisms U.S. Council for TMM c/o Univ. Mass., Dept. ME Amherst, MA 01002
INCE:	Institute of Noise Control Engineering P.O. Box 3206, Arlington Branch Poughkeepsie, NY 12603
ISA:	Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222
ONR:	Office of Naval Research Code 40084, Dept. Navy Arlington, VA 22217
SAE:	Society of Automotive Engineers 400 Commonwealth Drive Warrendale, PA 15096
SEE:	Society of Environmental Engineers Owles Hall, Buntingford, Herts. SG9 9PL, England
SESA:	Society for Experimental Stress Analysis 21 Bridge Sq. Westport, CT 06880
SNAME:	Society of Naval Architects and Marine Engineers 74 Trinity Pl. New York, NY 10006
SPE:	Society of Petroleum Engineers 6200 N. Central Expressway Dallas, TX 75206
SVIC:	Shock and Vibration Information Center Naval Research Lab., Code 5804 Washington, D.C. 20375
URSI-USNC:	International Union of Radio Science - U.S. National Committee c/o MIT Lincoln Lab. Lexington, MA 02173

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

The format and style for the list of References at the end of the article are as follows:

- each citation number as it appears in text (not in alphabetical order)
- last name of author/editor followed by initials or first name
- titles of articles within quotations, titles of books underlined
- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, number or issue, and pages for journals; publisher for books
- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).
2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addision-Wesley (1955).
3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).
4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).
5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).
6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).
7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

Articles for the DIGEST will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the DIGEST. Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 1500 to 2500 words in length. For additional information on topics and editorial policies, please contact:

Milda Z. Tamulionis
Research Editor
Vibration Institute
101 W. 55th Street, Suite 206
Clarendon Hills, Illinois 60514